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(54) Iron core of rotating-electric machine and manufacturing method for the same

(57) An iron core of a rotating-electric machine and a manufacturing method for the same permit a uniform curvature to be easily obtained over an entire circumference of the iron core. The iron core has laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the core proximal portion, and slots for accommodating a winding that are located between the

teeth adjacent to each other. The iron core is fabricated by curving both end portions of a substantially hexahedral laminate so that the core proximal portion obtains a predetermined curvature, forming the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion, and joining both end portions of the laminate.

FIG. 1A

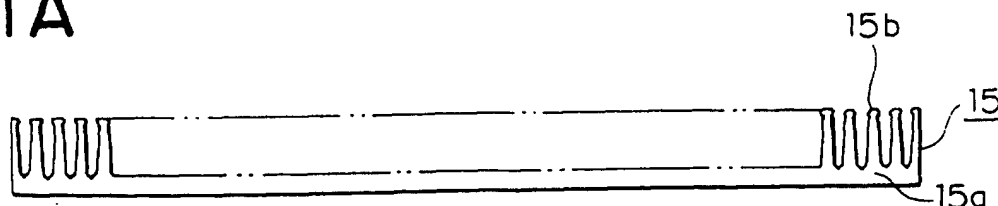


FIG. 1B

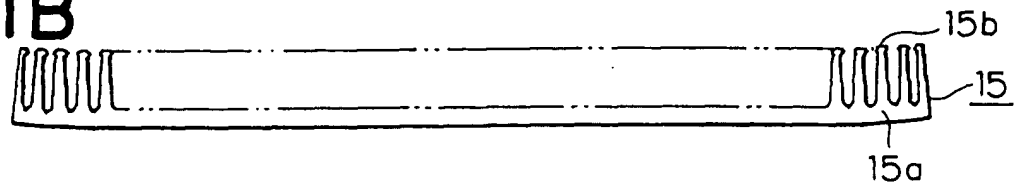
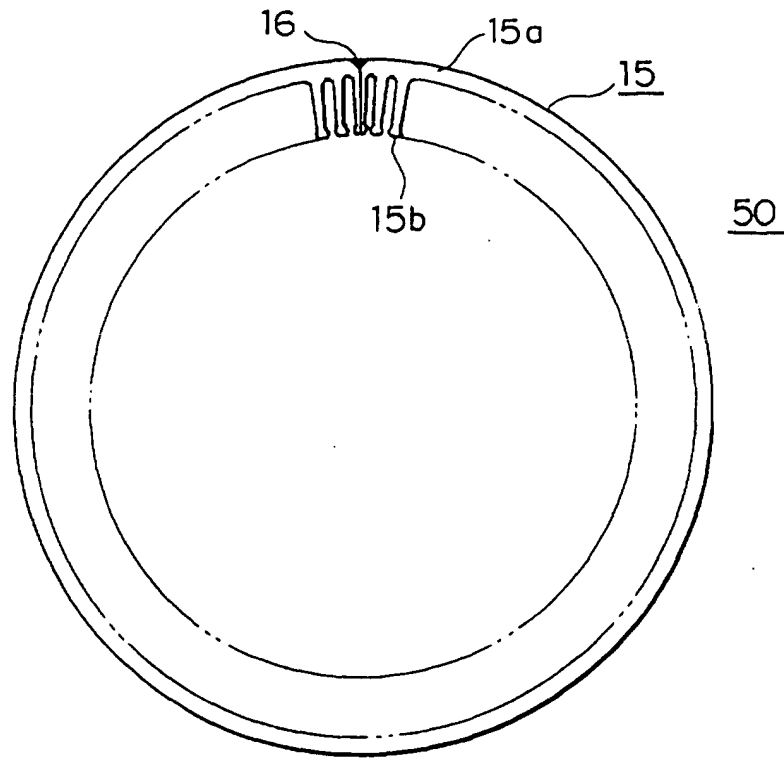


FIG. 1C



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an iron core of a rotating-electric machine and, more particularly, to an iron core of a rotating-electric machine composed of laminated steel plates, and a manufacturing method for the same.

2. Description of the Related Art

[0002] Fig. 21 is a perspective view of a laminate used for an iron core of a conventional rotating-electric machine disclosed in, for example, Japanese Unexamined Patent Application Publication No. 48-9201. Fig. 22 shows a laminate of the iron core being formed by wrapping it around a cylindrical core member. Fig. 23 shows the formed iron core with its both end portions joined. A laminate 5 is fabricated by laminating a predetermined number of straight magnetic strips which are blanked out, and has a core proximal portion 5a and a plurality of teeth 5b equidistantly arranged. The laminate 5 that has been formed into a substantially hexahedral shape is wound with a winding (not shown), wrapped around a cylindrical core member 9 into a cylindrical shape, and an abutting portion 10 where both end portions thereof are abutted against each other is welded to join the end portions.

[0003] In the conventional iron core of a rotating-electric machine described above, as set forth above, a plurality of slots for accommodating the winding are formed in the magnetic strips, and the magnetic strips with the slots are stacked to form the substantially hexahedral laminate 5. The laminate 5 is wound around the cylindrical core member 9 to be shaped into a cylinder, and both end portions thereof are joined.

[0004] Such a conventional iron core 40 of a rotating-electric machine is not a cylindrical iron core from the start. Winding work can be facilitated by wrapping a winding (not shown) around the substantially hexahedral laminate 5. There is an advantage in that, since the laminated 5 is curved after installing the winding, a sectional area of a slot after curving becomes smaller than that before curving, thus allowing the winding to be disposed at a higher density.

[0005] On the other hand, in the case of the conventional iron core 40 of the rotating-electric machine having the construction described above, portions in the vicinity of both end portions are formed to have larger-radius curves than a curve of the remainder thereof, so that joining surfaces of the abutting end portions do not snugly meet, leading to unsuccessful joining when the virtually hexahedral laminate 5 is wrapped around the cylindrical core member into a cylindrical shape. More specifically, the curves near the abutting portion 10 are

insufficient, and a curvature radius is uneven over an entire circumference, presenting a problem in that joining surfaces are misaligned, resulting in unsuccessful joining.

[0006] There has been another problem in that forcibly meeting the abutting portion 10 deteriorates the roundness of the iron core.

[0007] Furthermore, in the conventional iron core 40 of a rotating-electric machine having the above construction, there has been still another problem in that wavy deformation as shown in Fig. 24 occurs when the iron core 40 is cylindrically wound around the cylindrical core member 9.

[0008] There has been yet another problem in that bending rigidity at both end portions of the virtually hexahedral laminate 5 is high, and a large force is required for curving the end portions, causing a tooth portion 5b to buckle.

SUMMARY OF THE INVENTION

[0009] Accordingly, the present invention has been made with a view toward solving the problems described above, and it is an object thereof to provide an iron core of a rotating-electric machine capable of allowing a curvature of the iron core to be easily made uniform over its entire circumference, permitting roundness of the cylindrical iron core to be improved, preventing the occurrence of wavy deformation and also preventing a tooth portion from buckling or deforming, allowing a reduced space between a magnetic pole or a magnet opposing the iron core to be achieved, allowing lower magnetic resistance of an air gap, and permitting an output of the rotating-electric machine to be increased. Another object of the present invention is to provide a manufacturing method for the iron core of the rotating-electric machine described above.

[0010] To this end, according to one aspect of the present invention, there is provided an iron core of a rotating-electric machine, which iron core is constructed by laminated magnetic plate strips; a cylindrical core proximal portion; a plurality of teeth projecting in a substantially radial direction from the core proximal portion; and slots for accommodating a winding that are located between the teeth adjacent to each other, wherein the iron core is fabricated by curving both end portions of a substantially hexahedral laminate so that the core proximal portion obtains a predetermined curvature, forming the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion, and joining both end portions of the laminate.

[0011] In a preferred form, both end portions of the core proximal portion of a laminate have a lower rigidity than that of the remainder thereof.

[0012] In another preferred form, both end portions of the core proximal portion of the laminate are provided with thinner portions that are thinner in a radial direction

so as to have a lower rigidity.

[0013] In yet another preferred form, a filling member for making a diameter of a circumferential end portion of the core proximal portion identical to that of the remainder is welded to the thinner portions.

[0014] In still another preferred form, both end portions of the core proximal portion of the laminate are formed so that the diameter of the circumferential end portion of the core proximal portion becomes smaller toward an end thereof so as to reduce the rigidity thereof.

[0015] In a further preferred form, both end portions of the core proximal portion of the laminate are provided with at least one notch each at a location adjacent to the circumferential end portion of the core proximal portion so as to reduce the rigidity thereof.

[0016] In a further preferred form, the iron core of the rotating-electric machine is formed by curving a single virtually hexahedral laminate.

[0017] According to another aspect of the present invention, there is provided a manufacturing method for an iron core of a rotating-electric machine, the iron core including laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the proximal core portion, and slots for accommodating a winding that are located between adjoining teeth, the manufacturing method including: an end portion curving step for curving both end portions of a substantially hexahedral laminate of the iron core so that the core proximal portion obtains a predetermined curvature; a body curving step for curving the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion; and a joining step for joining both end portions of the laminate.

[0018] In a preferred form, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and the end portions of the laminate are curved by pressing the end portions in a direction in which the teeth project by a pressing jig in the end portion curving step, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth toward an end thereof.

[0019] In another preferred form, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and a closely contacting jig having an L-shaped section is placed in close contact with a corner of the core proximal portion of the end of the laminate, and the end portions of the laminate are curved using the closely contacting jig such that they are wrapped toward the teeth, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth to-

ward an end thereof.

[0020] In a further preferred form, the iron core is formed by curving a single laminate having a substantially hexahedral shape, and the body curving step includes: a first body curving step in which a central portion of the laminate is clamped, and both end portions of a predetermined length from ends are wrapped around a cylindrical core member; and a second body curving step in which the curved portions that have been formed in the first step are clamped and the remaining central portion is curved by wrapping it around the core member.

[0021] According to still another aspect of the present invention, there is provided a manufacturing method for an iron core of a rotating-electric machine constructed by laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the core proximal portion, and slots for accommodating a winding that are formed between the teeth adjacent to each other, the manufacturing method including: a body curving step for wrapping a central portion of a laminate around a cylindrical core member to form the laminate into a cylindrical shape such that distal ends of teeth project from the core proximal portion; an end portion curving step for clamping the laminate, which has been curved in the body curving step, at inner and outer peripheries except end portions thereof and curving the end portions of the laminate by pressing or wrapping the end portions toward the inner periphery thereof; and a joining step for joining both end portions of the laminate.

[0022] In a preferred form, the manufacturing method includes a step for accommodating a winding in slots of the substantially hexahedral laminate before at least the body curving step, and the body curving step is implemented with the winding accommodated in the slots.

[0023] In a further preferred form, the body curving step is carried out while at least a part of the core proximal portion of the laminate is slidably guided from both sides.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Fig. 1 illustrates a manufacturing process of an iron core of a rotating-electric machine in accordance with the present invention, wherein Fig. 1A is a side view of a substantially hexahedral laminate, Fig. 1B is a side view of the laminate with its both end portions curved, and Fig. 1C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

[0025] Fig. 2 is a side view of an essential section showing another embodiment of the iron core of a rotating-electric machine in accordance with the present invention.

[0026] Fig. 3 presents side views of an essential section showing yet another embodiment of the iron core of the rotating-electric machine in accordance with the present invention, wherein Fig. 3A is a side view show-

ing a recessed section in the vicinity of a junction, the recessed section being in the process of filling, and Fig. 3B is a side view showing the recessed section in the vicinity of the junction, the recessed section having been filled.

[0027] Fig. 4 is a side view showing an essential section of a further embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0028] Fig. 5 is a side view showing an essential section of a still another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0029] Fig. 6 is a side view showing an essential section of yet another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0030] Fig. 7 is a side view showing a state wherein an end of the substantially hexahedral laminate is being curved in an end portion curving step.

[0031] Fig. 8 is a diagram showing a distribution of internal stress generated when the end portion is curved by the method illustrated in Fig. 7.

[0032] Fig. 9 is a side view showing an end of a laminate being curved according to a manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention.

[0033] Fig. 10 is a side view showing an end of a laminate being curved according to another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention.

[0034] Fig. 11 is a process diagram showing an end of a laminate being curved according to yet another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention.

[0035] Fig. 12 is a diagram showing a distribution of internal stress generated when the end portion is curved by the method illustrated in Fig. 11.

[0036] Fig. 13 is a process diagram showing a procedure for curving a laminate according to still another embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0037] Fig. 14 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0038] Fig. 15 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0039] Fig. 16 is a diagram showing further details of the step for accommodating a winding shown in Fig. 15A.

[0040] Fig. 17 is a perspective view illustrating how the laminate is curved according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0041] Fig. 18 illustrates a manufacturing process of another embodiment of an iron core of a rotating-electric machine in accordance with the present invention, wherein Fig. 18A is a side view of a substantially hexahedral laminate, Fig. 18B is a side view of the laminate with its both end portions curved, and Fig. 18C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

[0042] Fig. 19 is a process diagram showing how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0043] Fig. 20 is a perspective view illustrating how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0044] Fig. 21 is a perspective view of a substantially hexahedral laminate constituting a conventional iron core of a rotating-electric machine.

[0045] Fig. 22 is a diagram showing an iron core composed of the laminate being formed by wrapping it around a cylindrical core member.

[0046] Fig. 23 is a diagram showing both end portions of the cylindrically formed iron core being joined.

[0047] Fig. 24 is a perspective view showing wavy deformation of an iron core observed when a laminate is curved.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

[0048] Fig. 1 is a diagram showing a manufacturing process of an iron core of a rotating-electric machine in accordance with the present invention. Fig. 1A is a side view of a substantially hexahedral laminate, Fig. 1B is a side view of the laminate with its both end portions curved, and Fig. 1C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

[0049] To fabricate a laminate 15, first, a plurality of linear magnetic strips, each having a core proximal portion 15a and a plurality of teeth 15b, are prepared by blanking out as in the case of the prior art, and the magnetic strips are laminated to fabricate the substantially hexahedral laminate 15 as shown in Fig. 1A.

[0050] Then, both end portions of the virtually hexahedral laminate 15 are curved at a predetermined curvature so that distal ends of the teeth 15b are oriented toward a center as shown in Fig. 1B (an end portion

curving step). The predetermined curvature in this case is approximate to a curvature of a finished cylindrical iron core 50 or an iron core after curving the body of the laminate.

[0051] Lastly, as illustrated in Fig. 1C, the entire laminate 15 is cylindrically formed by wrapping it around a cylindrical core member (not shown) such that the distal ends of the teeth 15b are oriented to an inner periphery (a body curving step), and a joining portion 16 where both end portions of the laminate 15 abut against each other is welded by laser welding or electron beam welding (a joining step).

[0052] Lastly, the laminate 15 is formed into an iron core 50 that has the cylindrical core proximal portion 15a and the plural teeth 15b jutting out toward an axial center from the core proximal portion 15a, and is provided with slots for accommodating a winding, the slots being located between adjacent teeth.

[0053] In the iron core 50 of a rotating-electric machine constructed as described above, the end portions of the virtually hexahedral laminate 15 are curved in the end portion curving step, then the laminate 15 is formed into a cylindrical shape by wrapping the laminate 15 around a cylindrical core member in the body curving step. This arrangement permits an iron core to have uniform curvature over its entire circumference with consequent improved roundness of the cylindrical iron core 50. The improved roundness of the iron core 50 makes it possible to reduce a gap relative to a magnetic member disposed, facing against the iron core 50, permitting magnetic resistance in the gap to be reduced. Hence, an output of the rotating-electric machine can be improved.

Second Embodiment

[0054] Fig. 2 is a side view of an essential section illustrating another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0055] In a laminate 115 in this embodiment, portions on the outer periphery side of both end portions of the core proximal portion 15a are cut off, and a thinner portion 15c having a smaller thickness to reduce an outside diameter of the core proximal portion 15a is provided. This reduces the rigidity of both end portions. Fig. 2 shows only one end, whereas the thinner portion 15c is provided on both end portions of the laminate 115. The rest of the construction of this embodiment is identical to the construction of the first embodiment.

[0056] In the iron core of the rotating-electric machine configured as set forth above, the thinner portions 15c provided on both end portions of the substantially hexahedral laminate 115 permit the end portions to be curved more easily, and a force required for curving the end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of the teeth 15b.

Third Embodiment

[0057] Fig. 3 presents side views of an essential section showing yet another embodiment of the iron core of the rotating-electric machine in accordance with the present invention. Fig. 3A is a side view showing a recessed section in the vicinity of a junction, the recessed section being in the process of filling, and Fig. 3B is a side view showing the recessed section in the vicinity of the junction, the recessed section having been filled.

[0058] In the laminate 115 of the second embodiment described above, the portions on the outer periphery side of both end portions of a core proximal portion 15a are cut off, and the thinner portions 15c having a smaller thickness to reduce the outside diameter of the proximal portion 15a are provided on the end portions so as to lessen the rigidity of the end portions.

[0059] In an iron core 50 fabricated as described above, both end portions of the laminate 115 are joined in a joining step, then the recessed sections are formed in the vicinity of the junction on the outer periphery side. In general, when the proximal portion 15a of the iron core has a portion having a smaller radial width, magnetic saturation occurs due to the portion, resulting in a lower output of the rotating-electric machine.

[0060] In the third embodiment, to solve the problem mentioned above, a filling piece 17 for filling the thinner portions 15c forming the recessed section is welded so as to make the outside diameter of the thinner portions 15c identical to the remainder. The filling piece has a configuration that snugly fits in the recessed section, and is welded at both end portions (junctions 16b and 16c) by laser welding or electron beam welding.

[0061] The rest of the construction of the third embodiment is the same as the construction of the second embodiment.

[0062] In the iron core 50 of the rotating-electric machine configured as set forth above, the core proximal portion 15a has no portion of a smaller radial width, so that likelihood of the occurrence of magnetic saturation is reduced, leading to higher output of the rotating-electric machine. Furthermore, welding the filling piece 17 improves the strength of the iron core.

Fourth Embodiment

[0063] Fig. 4 is a side view showing an essential section of a further embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0064] In a laminate 215 of this embodiment, slope portions 15d are formed on both end portions of a core proximal portion 15a so that an outside diameter of the proximal portion grows smaller toward the end portions, thus reducing the rigidity thereof.

[0065] The rest of the construction of the fourth embodiment is the same as that of the first embodiment.

[0066] In an iron core 50 of the rotating-electric ma-

chine configured as set forth above, both end portions of the substantially hexahedral laminate 215 permits both end portions to be curved easily, and a force required for curving both end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of teeth 15b. Moreover, the simple configuration permits easy machining of the end portions.

Fifth Embodiment

[0067] Fig. 5 is a side view showing an essential section of a still another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0068] In a laminate 315 of this embodiment, both end portions of a core proximal portion 15a are provided with notches 15e, whose sections are shaped like narrow slots, at the outer periphery side thereof so as to reduce the rigidity.

[0069] The rest of the configuration is the same as the configuration of the first embodiment.

[0070] In an iron core 50 of the rotating-electric machine configured as described above, both end portions of the substantially hexahedral laminate 315 can be curved easily, and a force required for curving both end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of teeth 15b. Moreover, the simple configuration permits easy machining of the end portions.

Sixth Embodiment

[0071] Fig. 6 is a side view showing an essential section of a further embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0072] In a laminate 415 of this embodiment, both end portions of a core proximal portion 15a are provided with notches 15f, whose sections are triangular, at the outer periphery side thereof so as to reduce the rigidity.

[0073] The rest of the configuration is the same as the configuration of the first embodiment.

[0074] In an iron core 50 of the rotating-electric machine configured as described above, both end portions of the substantially hexahedral laminate 415 can be curved easily, and a force required for curving both end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of teeth 15b. Moreover, the simple configuration permits easy machining of the end portions.

Seventh Embodiment

[0075] Fig. 7 is a side view showing a state wherein an end of the substantially hexahedral laminate is being curved. Fig. 8 is a diagram showing a distribution of internal stress generated when the end portion is curved

by the method illustrated in Fig. 7. In Fig. 8, a darker shade denotes an area to which a higher stress is applied.

[0076] In a method for curving the two end portions of a substantially hexahedral laminate 15 shown in Fig. 7, the laminate 15 is clamped by a first fixing jig 61 disposed on a core proximal portion 15a and a second fixing jig 62 disposed on teeth 15b so that end portions jut out by a predetermined length. A pressing jig 71 is abutted against the end of the core proximal portion 15a of the laminate 15, and the laminate 15 is pressed vertically or in the direction in which the teeth 15b project.

[0077] This method has been posing a problem in that a high stress is applied to a second tooth 15b1 from the end to be curved as shown in Fig. 8, causing the second tooth 15b1 to buckle.

[0078] Fig. 9 is a side view showing a step for curving the end of the laminate according to the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention. According to the manufacturing method for an iron core of this embodiment, the end of the second fixing jig 63 adjacent to the teeth 15b is provided with a linear slope 63a formed to be distanced farther from the teeth 15b toward the end in the vicinity of a location where the second tooth 15b1 from the end abuts the jig. This arrangement protects the second tooth 15b1 from the end to be curved from an excessive stress, thus preventing the second tooth 15b1 from buckling.

[0079] In the manufacturing method for an iron core of a rotating-electric machine described above, both end portions of the laminate are curved to have a final curvature according to the above method before the entire laminate is formed into a cylindrical shape by wrapping it around a cylindrical core member. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of a cylindrical iron core 50. The improved roundness of the iron core 50 allows a reduced gap relative to a rotator opposing the iron core, and a magnetic resistance in the gap can be reduced. Hence, a higher output of the rotating-electric machine can be accomplished.

[0080] Moreover, the end portions can be curved simply by pressing them in the direction in which the teeth 15b project, permitting the machining procedure to be simplified. In addition, the slope 63a makes it possible to set the angle at which the teeth 15b abut the second fixing member 63 at an appropriate angle, lessening the possibility of buckle or deformation of the teeth 15b, which interfere with curving.

Eighth Embodiment

[0081] Fig. 10 is a side view showing an end of a laminate being curved according to another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present inven-

tion.

[0082] In the manufacturing method for the iron core of this embodiment, the end of a second fixing jig 64 adjacent to the teeth 15b is provided with an arc slope 64a formed to be distanced farther from the teeth 15b toward the end in the vicinity of a location where the second tooth 15b1 from the end abuts the jig.

[0083] The rest of the configuration of this embodiment is the same as the configuration of the seventh embodiment.

[0084] In the manufacturing method for the iron core of the rotating-electric machine described above, the arc slope 64a makes it possible to set the angle at which the teeth 15b abut the second fixing member 64 to a further appropriate angle, thus further lessening the possibility of buckle or deformation of the teeth 15b, which interfere with curving.

Ninth Embodiment

[0085] Fig. 11 is a process diagram showing an end of a laminate being curved according to yet another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention. Fig. 12 is a diagram showing a distribution of internal stress generated when the end portion is curved by the method illustrated in Fig. 11. In Fig. 12, a darker shade denotes an area to which a higher stress is applied.

[0086] In this embodiment, as in the case of the eighth embodiment, the end of a second fixing jig 64 adjacent to the teeth 15b is provided with an arc slope 64a formed to be distanced farther from the teeth 15b toward the end in the vicinity of a location where the second tooth 15b1 from the end abuts the jig.

[0087] Further, in this embodiment, a closely contacting jig 72 having an L-shaped section is brought into close contact with a corner of the end of the core proximal portion 15a of the laminate 15 as shown in Fig. 11A, and the end portion of the laminate 15 is curved to wrap toward teeth 15b as shown in Fig. 11B by using the closely contacting jig 72.

[0088] In this embodiment, the slope 64a combined with the curving method using the closely contacting jig 72 for wrapping-like curving hardly apply a stress to the second tooth 15b1 as can be seen from Fig. 12.

[0089] In the manufacturing method for the iron core of the rotating-electric machine described above, the arc slope 64a makes it possible to set the angle at which the teeth 15b abut the second fixing member 64 to an appropriate angle, thus further lessening the possibility of buckle of the teeth 15b. Moreover, since the end portion is curved to wrap using the closely contacting jig 72, a curving moment can be applied to the portion of the laminate 15 to be curved while reducing the stress applied to the teeth 15b at a position away from the end by a predetermined distance. This makes it possible to further lessen the possibility of buckle of the teeth 15b.

Tenth Embodiment

[0090] Fig. 13 is a process diagram showing a procedure for curving a laminate according to still another embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0091] In this embodiment, as shown in Fig. 13A, both end portions of a laminate 15 are curved at a predetermined curvature so that distal ends of the teeth 15b are oriented toward a center according to the method of the eighth embodiment (an end portion curving step).

[0092] Then, as illustrated in Fig. 13B, a central portion of the laminate 15 is clamped, and both end portions, each having a quarter length from the end, are curved by being wrapped around cylindrical core members 73 (a first body curving step).

[0093] Next, as illustrated in Fig. 13C, one of the portions that have been curved by the quarter length in the first body curving step is held, and the remaining uncurved central portion is curved by being wrapped around the core member 73 (a second body curving step).

[0094] Lastly, as shown in Fig. 13D, both end portions of the laminate abutting each other are joined by laser welding or electron beam welding (a joining step).

[0095] According to the manufacturing method for the iron core of the rotating-electric machine described above, a wide area of the central portion is clamped, so that the end portions can be easily wound onto the core members.

Eleventh Embodiment

[0096] Fig. 14 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0097] In this embodiment, end portions of a laminate 15 are not curved in a first step. According to the embodiment, the entire laminate 15 is curved according to the procedure illustrated in Fig. 13B and Fig. 13C of the tenth embodiment (a body curving step).

[0098] Then, as shown in Fig. 14A, the laminate 15, which has been curved in the foregoing body curving step, is clamped at its entire inner and outer peripheries except for its end portions. A closely contacting jig 72 having an L-shaped section is brought into close contact with a corner of an end of a core proximal portion 15a of the laminate 15, and the end portion of the laminate 15 is curved to wrap toward teeth 15b by using the closely contacting jig 72 (an end portion curving step).

[0099] Thereafter, as illustrated in Fig. 14B and Fig. 14C, both end portions of the laminate are abutted each other and joined by laser welding or electron beam welding (a joining step).

[0100] The manufacturing method for an iron core of

a rotating-electric machine described above makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a rotator opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Furthermore, the laminate is held at inner and outer peripheries thereof other than the end portions when curving the end portions, thus ensuring firm support. Hence, the occurrence of buckle of teeth 15b can be further reduced.

Twelfth Embodiment

[0101] Fig. 15 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention. Fig. 16 is a diagram showing further details of a step for accommodating a winding shown in Fig. 15A.

[0102] This embodiment has a step for accommodating a winding 80 in slots of a substantially hexahedral laminate 15 (a winding accommodating step) as shown in Fig. 15A prior to the body curving step of the first embodiment. In the winding accommodating step, the winding 80 and an insulator 81, which is interposed between the winding 80 and the laminate 15, are accommodated in the slots as shown in Fig. 16.

[0103] Thereafter, in the same manner as that of the first embodiment, the body curving step and the joining step are implemented except that these two steps are carried out with the winding 80 accommodated in the slots.

[0104] The manufacturing method for an iron core of a rotating-electric machine described above makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a rotator opposing the iron core, and a magnetic resistance in the gap can be reduced, so that an output of a rotating-electric machine can be increased. Furthermore, the winding 80 is accommodated in the substantially hexahedral laminate 15, permitting an easy accommodating operation. In addition, sectional areas of the slots decrease after curving. Therefore, an occupancy of the winding in the slots can be increased, and the output of the rotating-electric machine can be improved.

[0105] The aforesaid winding accommodating step can be carried out before the body curving step in any one of the methods according to the first to eleventh embodiments. Subsequent steps can be carried out with the winding 80 accommodated in the slots.

Thirteenth Embodiment

[0106] Fig. 17 is a perspective view illustrating how the laminate is curved according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0107] In this embodiment, a body curving step is implemented using a slidable forming jig 74 for guiding on both side surfaces of a core proximal portion 15a of a laminate 15. Flanges 74a formed on both edges of the forming jig 74 abut both side surfaces of the core proximal portion 15a with slight clearances therebetween to perform guidance in a slidable state.

[0108] According to the manufacturing method for an iron core of a rotating-electric machine described above, the flanges 74a of the forming jig 74 guide the laminate 15 to prevent the laminate 15 from deforming in a direction of lamination. This arrangement allows the possibility of wavy deformation of the laminate 15 to be decreased.

[0109] The forming jig in this embodiment can be used for the body curving step in the first to twelfth embodiments.

Fourteenth Embodiment

[0110] Fig. 18 illustrates a manufacturing process of another embodiment of an iron core of a rotating-electric machine in accordance with the present invention. Fig. 18A is a side view of a substantially hexahedral laminate, Fig. 18B is a side view of the laminate with its both end portions curved, and Fig. 18C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

[0111] An iron core of a rotating-electric machine according to this embodiment is an iron core 90 employed with, for example, a rotor of a motor. The iron core 90 is composed of laminated magnetic strips, and has a cylindrical core proximal portion 15a, a plurality of teeth 15b radially projecting outward from the core proximal portion 15a, and slots formed between adjacent teeth 15b to accommodate a winding.

[0112] To fabricate a laminate 15, first, a plurality of linear magnetic strips, each having a core proximal portion 15a, and a plurality of teeth 15b are prepared by blanking out as in the case of the prior art, and the magnetic strips are laminated to fabricate the substantially hexahedral laminate 15 as shown in Fig. 18A.

[0113] Then, both end portions of the virtually hexahedral laminate 15 are curved at a predetermined curvature so that distal ends of the teeth 15b are radially spread at predetermined intervals as shown in Fig. 18B (an end portion curving step). The predetermined curvature in this case is approximate to a curvature of a finished cylindrical iron core 90 or an iron core after curving the body of the laminate.

[0114] Lastly, as illustrated in Fig. 18C, the entire lam-

inate 15 is cylindrically formed by wrapping it around a cylindrical core member (not shown) such that the distal ends of the teeth 15b are oriented to an outer periphery (a body curving step), and a joining portion where both end portions of the laminate 15 abut against each other is welded by laser welding or electron beam welding (a joining step).

[0115] In the iron core 90 of a rotating-electric machine constructed as described above, the end portions of the virtually hexahedral laminate 15 are curved in the end portion curving step, then the laminate 15 is formed into a cylindrical shape by wrapping the laminate 15 around a cylindrical core member in the body curving step. This arrangement permits an iron core to have a uniform curvature over its entire circumference with consequent improved roundness of the cylindrical iron core 90. The improved roundness of the iron core 90 makes it possible to reduce a gap relative to a magnetic pole or a magnet disposed, facing against the iron core 90, permitting magnetic resistance in the gap to be reduced. Hence, an output of the rotating-electric machine can be improved.

Fifteenth Embodiment

[0116] Fig. 19 is a process diagram showing how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0117] According to this embodiment, a fabricating method associated with the eleventh embodiment is applied to fabricate the iron core 90 in the fourteenth embodiment. In this embodiment, end portions of a laminate 15 are not curved in a first step. In the embodiment, the entire laminate 15 is curved according to the procedure illustrated in Fig. 13B and Fig. 13C of the tenth embodiment (a body curving step).

[0118] Thereafter, as illustrated in Fig. 19, the laminate 15 that has been curved in the foregoing body curving step is clamped at entire inner and outer peripheries thereof except for end portions. Then, a closely contacting jig 72 having an L-shaped section is brought into close contact with a corner of the end of teeth 15b of the laminate 15, and the end of the laminate 15 is curved to wrap toward a core proximal portion 15a by the closely contacting jig 72 (an end portion curving step).

[0119] The manufacturing method for an iron core of a rotating-electric machine described above makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Furthermore, the laminate is held at inner and outer peripheries thereof

other than the end portions when curving the end portions, thus ensuring firm support. Hence, the occurrence of buckle of teeth 15b can be further reduced.

5 Sixteenth Embodiment

[0120] Fig. 20 is a perspective view illustrating how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0121] According to this embodiment, a fabricating method associated with the thirteenth embodiment is applied to fabricate the iron core 90 in the fourteenth embodiment.

[0122] In this embodiment, a body curving step is implemented using a slidable forming jig 75 for guiding on both side surfaces of a core proximal portion 15a of a laminate 15. Flanges 75a formed on both edges of the forming jig 75 abut both side surfaces of the core proximal portion 15a with slight clearances therebetween to perform guidance in a slidable state.

[0123] According to the manufacturing method for an iron core of a rotating-electric machine described above, the flanges 75a of the forming jig 75 guide the laminate 15 to prevent the laminate 15 from deforming in a direction of lamination. This arrangement allows wavy deformation of the laminate 15 to be controlled.

[0124] As described above, an iron core of a rotating-electric machine in accordance with the present invention is constructed by laminated magnetic strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the core proximal portion, and slots for accommodating a winding that are located between the teeth adjacent to each other, wherein the iron core is fabricated by curving both end portions of a substantially hexahedral laminate so that the core proximal portion obtains a predetermined curvature, forming the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion, and joining both end portions of the laminate. Thus, both end portions of the laminate are curved to obtain a final curvature before the entire laminate is formed into a cylindrical shape by wrapping it around the cylindrical core member. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of a cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap is reduced. Hence, a higher output of the rotating-electric machine can be accomplished.

[0125] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate have a lower rigidity than that of the remainder thereof. With

this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, requiring a less force for curving the two end portions, and a uniform curvature of the iron core can be easily accomplished, permitting further improved roundness of the cylindrical iron core.

[0126] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate are provided with portions that are thinner in a radial direction so as to have a lower rigidity. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, requiring a less force for curving the two end portions, and a uniform curvature of the iron core can be easily accomplished, permitting further improved roundness of the cylindrical iron core.

[0127] In the iron core of a rotating-electric machine in accordance with the present invention, a filling member for filling the thinner portion for making a diameter of a circumferential end of the core proximal end identical to that of the remainder of the iron core is welded to the thinner portion. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, requiring a less force for curving the two end portions, and a uniform curvature of the iron core can be easily accomplished, permitting further improved roundness of the cylindrical iron core. Moreover, the core proximal portion has no portion of a smaller radial width since the portion recessed in the radial direction is filled with the filling piece, so that likelihood of the occurrence of magnetic saturation is reduced, leading to higher output of the rotating-electric machine. In addition, welding the filling piece improves the strength of the iron core.

[0128] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate are formed so that the diameter of the circumferential end portions of the core proximal end become smaller toward their ends so as to reduce rigidity. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, so that the force required for curving both end portions is reduced, and a uniform curvature of the iron core can be easily achieved, permitting further improved roundness of the cylindrical iron core. Moreover, the simple configuration of both end portions of the iron core permits easy machining of the end portions.

[0129] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate are provided with at least one notch each at the circumferential end portions of the core proximal portion so as to reduce the rigidity thereof. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, so that the force required for curving both end portions is reduced, and a uniform curvature of the iron core can be easily achieved, permitting further im-

proved roundness of the cylindrical iron core. Moreover, the simple configuration for reducing the rigidity permits easy machining of the end portions.

[0130] The iron core of a rotating-electric machine in accordance with the present invention is formed by curving a single virtually hexahedral laminate. Thus, a single substantially hexahedral laminate is used, so that only one joining step is required. Moreover, since there are fewer joining places, the strength of the iron core can be improved.

[0131] The manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the iron core including laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the proximal portion, and slots located between adjoining teeth to accommodate a winding, includes: an end portion curving step for curving both end portions of a substantially hexahedral laminate of the iron core so that the core proximal portion has a predetermined curvature, a body curving step for curving the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion, and a joining step for joining both end portions of the laminate. Hence, both end portions of the laminate are curved to have a final curvature before the entire laminate is wrapped around the cylindrical core member so as to be formed into the cylindrical shape. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of a cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap is reduced. Hence, a higher output of the rotating-electric machine can be accomplished.

[0132] According to the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and the end portions of the laminate are curved by pressing the end portions in a direction in which the teeth project by a pressing jig in the end portion curving step, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth toward an end thereof. Hence, the end portions can be curved simply by pressing them in the direction in which the teeth project, permitting the machining procedure to be simplified. In addition, the slope makes it possible to set the angle, at which the teeth abut the second fixing member, to an appropriate angle, lessening the possibility of buckle of the teeth.

[0133] According to the manufacturing method for an iron core of a rotating-electric machine in accordance

with the present invention, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and a closely contacting jig having an L-shaped section is placed in close contact with a corner on the core proximal portion of the end of the laminate, and the end portions of the laminate are curved using the closely contacting jig such that they are wrapped toward the teeth, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth toward an end thereof. Therefore, the slope makes it possible to set the angle, at which the teeth abut the second fixing member, to an appropriate angle, thus lessening the possibility of buckle of the teeth. Moreover, since the end portion is curved by wrapping, a curving moment can be applied to the portion of the laminate to be curved while reducing the stress applied to the teeth at a position away from the end by a predetermined distance. This makes it possible to further lessen the possibility of buckle of the teeth.

[0134] According to the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the iron core is formed by curving a single laminate having a substantially hexahedral shape, and the body curving step includes; a first body curving step in which a central portion of the laminate is clamped, and both end portions of a predetermined length from ends are curved by being wrapped around a cylindrical core member, and a second body curving step in which the curved portions that have been formed in the first step are clamped and the remaining central portion is curved by wrapping it around the core member. Hence, a single substantially hexahedral laminate is used, so that only one joining step is required, and the strength of the iron core can be improved since there are fewer joining places. Moreover, a wide area of the central portion is clamped, so that the end portions can be easily wound onto the core members

[0135] The manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the iron core being constructed by laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the core proximal portion, and slots for accommodating a winding that are formed between the teeth adjacent to each other, includes: a body curving step for wrapping a central portion of a laminate around a cylindrical core member to form the laminate into a cylindrical shape such that distal ends of teeth project from the core proximal portion; an end portion curving step for clamping the laminate, which has been curved in the body curving step, at inner and outer peripheries except end portions thereof and curving the end portions of the laminate by pressing or wrapping the end portions toward the inner periphery thereof; and a joining step for joining both end portions of the laminate.

This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Furthermore, the laminate is held at inner and outer peripheries thereof other than the end portions when curving the end portions, thus ensuring firm support, permitting the occurrence of buckle of teeth to be further reduced.

[0136] The manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention includes a step for accommodating a winding in slots of the substantially hexahedral laminate before at least the body curving step, and the body curving step is implemented with the winding accommodated in the slots. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Since the winding is accommodated in the substantially hexahedral laminate, the accommodating work is easy. Moreover, sectional areas of the slots decrease after curving; therefore, occupancy of the winding in the slots can be increased with a resultant higher output of the rotating-electric machine.

[0137] In the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the body curving step is carried out while at least a part of the core proximal portion of the laminate is slidably guided from both sides. Hence, the laminate is guided so as to prevent the laminate from deforming in a direction of lamination, allowing the possibility of wavy deformation of the laminate to be reduced.

Claims

1. An iron core of a rotating-electric machine, comprising:

laminated magnetic plate strips;
a cylindrical core proximal portion (15a);
a plurality of teeth (15b) projecting in a substantially radial direction from the proximal portion (15a); and
slots for accommodating a winding that are located between the teeth (15b) adjacent to each other,
wherein the iron core (50) is fabricated by curving both end portions of a substantially hexa-

- hedral laminate so that the core proximal portion (15a) obtains a predetermined curvature, forming the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member (73) so that distal ends of the teeth (15b) project from the core proximal portion (15a), and joining both end portions.
2. An iron core of a rotating-electric machine according to Claim 1, wherein both end portions of the core proximal portion (15a) of the laminate have a lower rigidity than that of the remainder thereof.
 3. An iron core of a rotating-electric machine according to Claim 2, wherein both end portions of the core proximal portion (15a) of the laminate are provided with thinner portions (15c) that are thinner in a radial direction so as to have a lower rigidity.
 4. An iron core of a rotating-electric machine according to Claim 3, wherein a filling member (17) for making a diameter of a circumferential end of the core proximal portion identical to that of the remainder is welded to the thinner portions (15c).
 5. A manufacturing method for an iron core of a rotating-electric machine, the iron core including laminated magnetic plate strips, a cylindrical core proximal portion (15a), a plurality of teeth (15b) projecting in a substantially radial direction from the core proximal portion (15a), and slots for accommodating a winding that are located between the teeth (15b) adjacent to each other, the manufacturing method comprising:
 - an end portion curving step for curving both end portions of a substantially hexahedral laminate so that the core proximal portion (15a) obtains a predetermined curvature;
 - a body curving step for curving the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member (73) so that distal ends of the teeth (15b) project from the core proximal portion; and
 - a joining step for joining both end portions of the laminate.
 6. A manufacturing method for an iron core of a rotating-electric machine according to Claim 5, wherein the laminate is clamped between a first fixing jig (61) disposed at the core proximal portion (15a) and a second fixing jig (63, 64) disposed on the teeth (15b) such that the end portions project by a predetermined length, and the end portions of the laminate are curved by pressing the end portions in a direction in which the teeth (15b) project by a pressing jig (71) in the end portion curving step, an end portion of the second fixing jig (63, 64) that is adja-

cent to the teeth being provided with an arc or linear slope (63a, 64a) that becomes farther from the teeth (15b) toward an end thereof.

7. A manufacturing method for an iron core of a rotating-electric machine according to Claim 5, wherein the laminate is clamped between a first fixing jig (61) disposed at the core proximal portion (15a) and a second fixing jig (63, 64) disposed at the teeth (15b) such that the end portions project by a predetermined length, and a closely contacting jig (72) having an L-shaped section is placed in close contact with a corner on the core proximal portion (15a) of the end of the laminate, and the end portions of the laminate are curved using the closely contacting jig (72) such that they are wrapped toward the teeth (15b), an end portion of the second fixing jig (63, 64) that is adjacent to the teeth being provided with an arc or linear slope (63a, 64a) that becomes farther from the teeth (15b) toward an end thereof.
8. A manufacturing method for an iron core of a rotating-electric machine according to any one of Claims 5 to 7, wherein
 - the iron core (50) is formed by curving a single laminate having a substantially hexahedral shape; and
 - the body curving step includes;
 - a first body curving step in which a central portion of the laminate is clamped, and both end portions of a predetermined length from ends are curved by being wrapped around a cylindrical core member (73), and
 - a second body curving step in which the curved portions that have been formed in the first step are clamped and a remaining central portion is curved by being wrapped around the core member.
9. A manufacturing method for an iron core of a rotating-electric machine constructed by laminated magnetic plate strips, a cylindrical core proximal portion (15a), a plurality of teeth (15b) projecting in a substantially radial direction from the core proximal portion (15a), and slots for accommodating a winding that are formed between the teeth (15b) adjacent to each other, the manufacturing method comprising:

- a body curving step for wrapping a central portion of a laminate around a cylindrical core member (73) to form the laminate into a cylindrical shape such that distal ends of teeth (15b) project from the core proximal portion (15a);
- an end portion curving step for clamping the laminate, which has been curved in the body curving step, at inner and outer peripheries ex-

cept end portions thereof, and curving the end portions of the laminate by pressing or wrapping the end portions toward the inner periphery thereof; and

a joining step for joining both end portions of the laminate. 5

10. A manufacturing method for an iron core of a rotating-electric machine according to any one of Claims 5 to 9, further comprising a step for accommodating the winding in the slots of the substantially hexahedral laminate before at least the body curving step; and 10

the body curving step is implemented with the winding accommodated in the slots. 15

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FIG. 1A

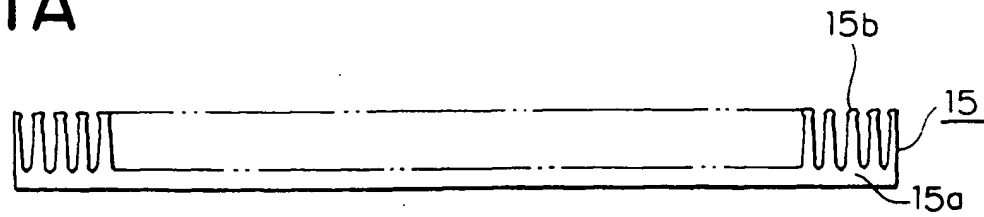


FIG. 1B

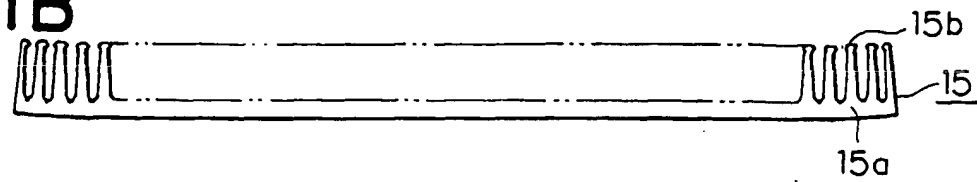


FIG. 1C

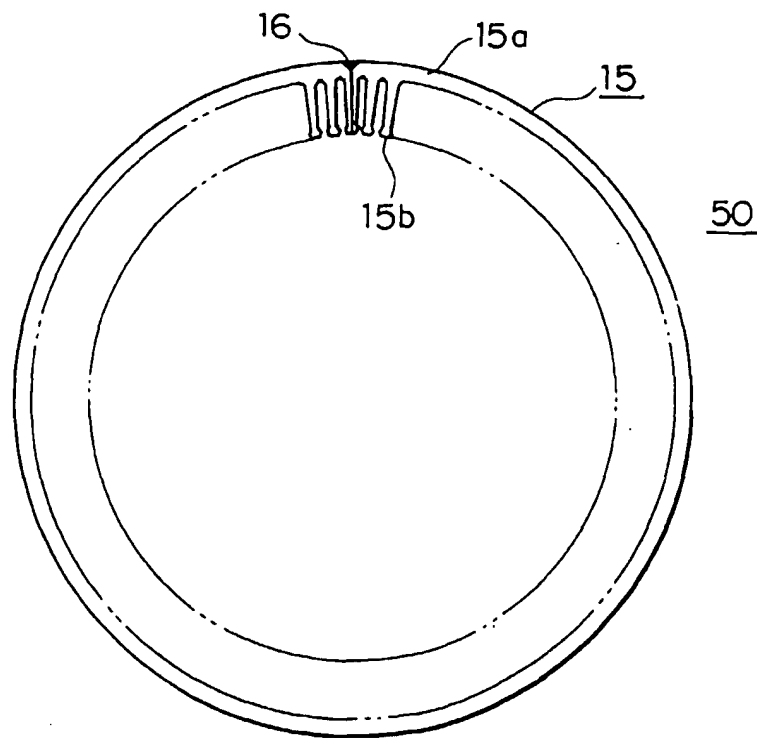


FIG. 2

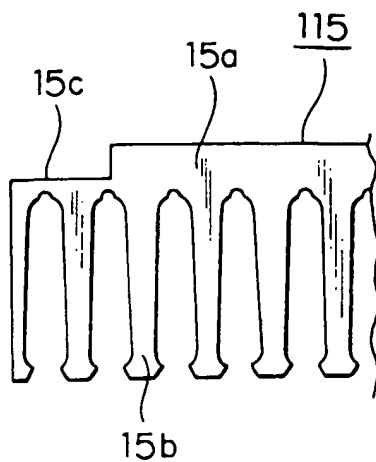


FIG. 3A

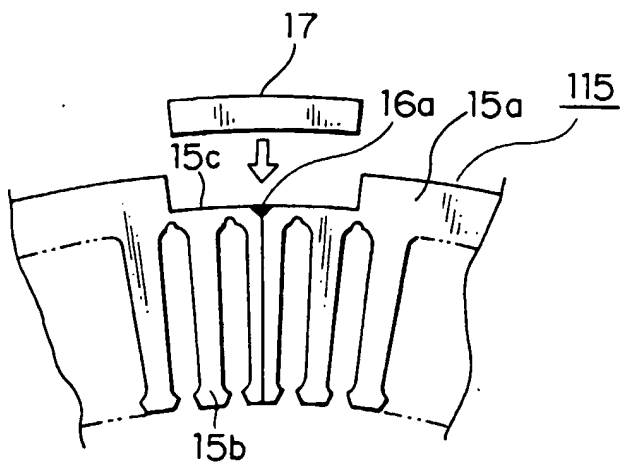


FIG. 3B

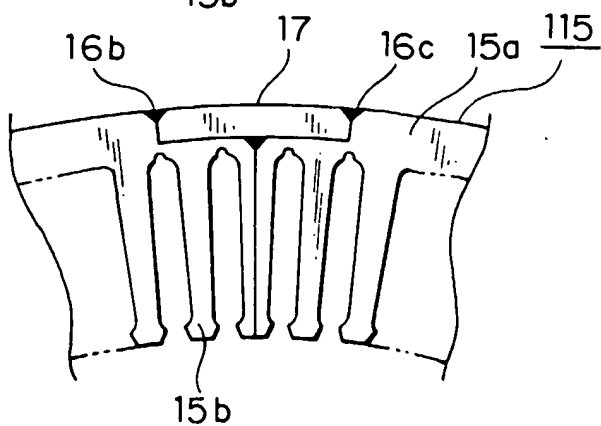


FIG. 4

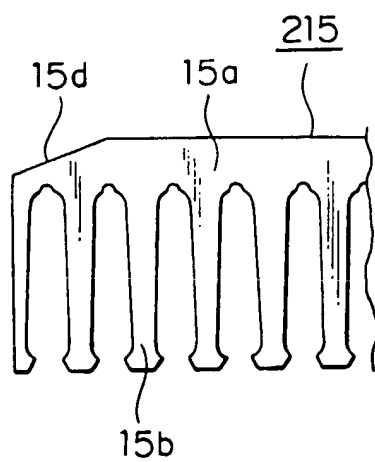


FIG. 5

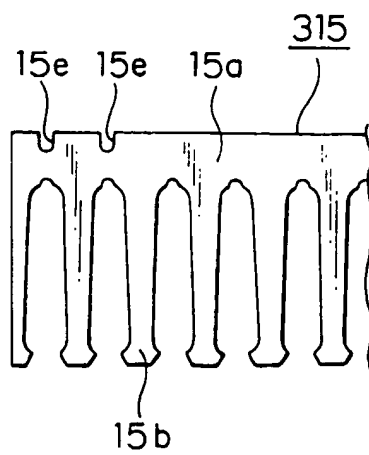


FIG. 6

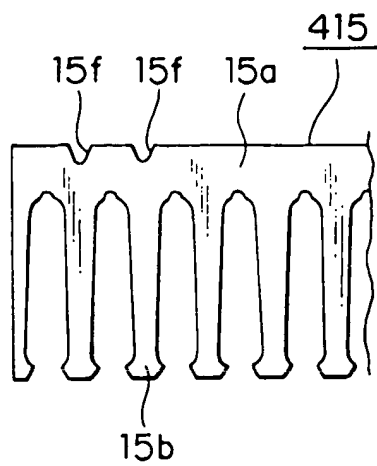


FIG. 7

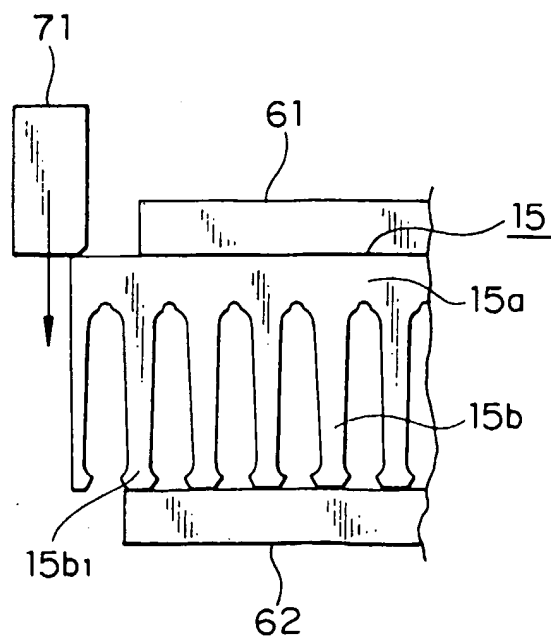


FIG. 8

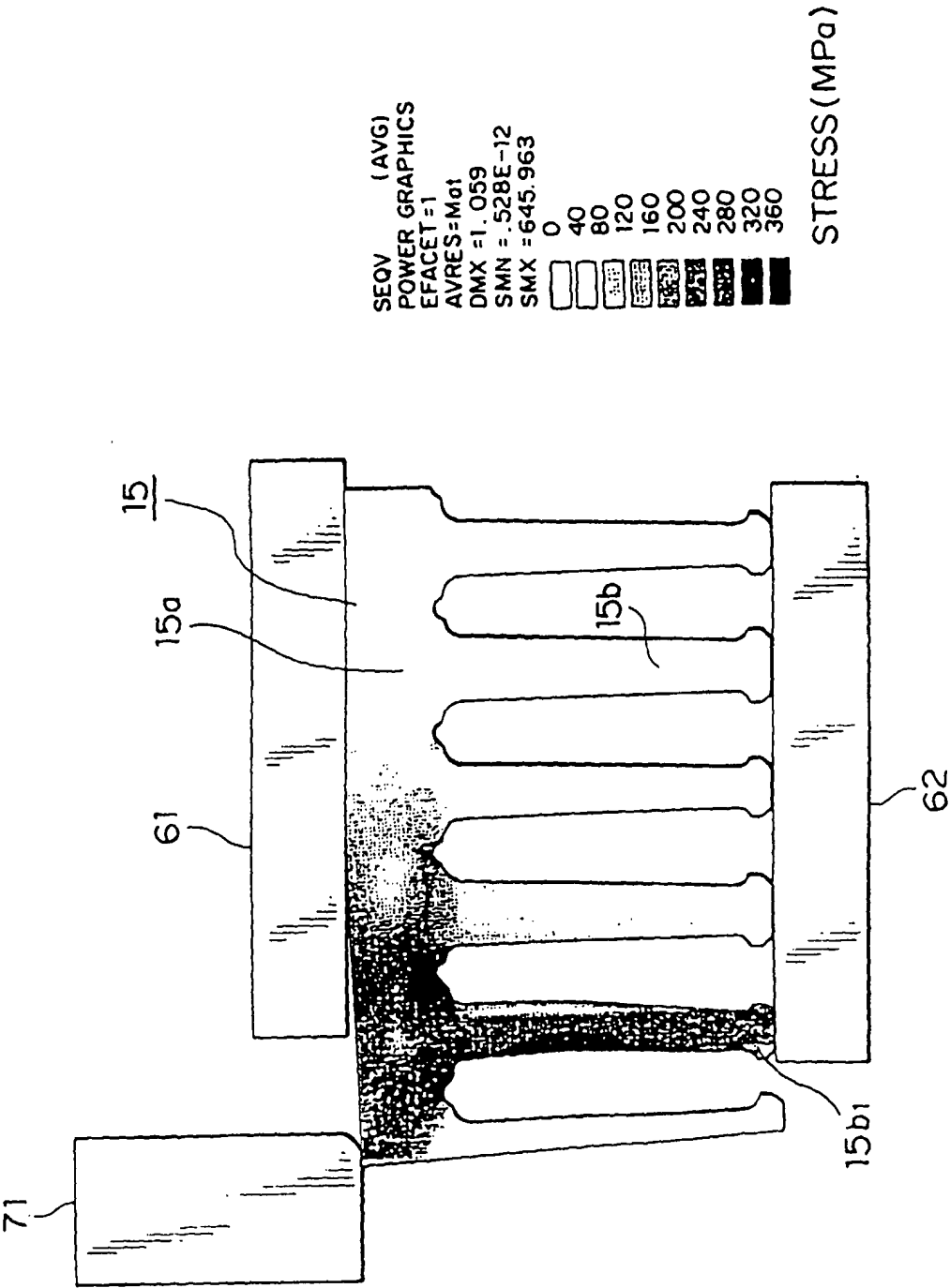


FIG. 9

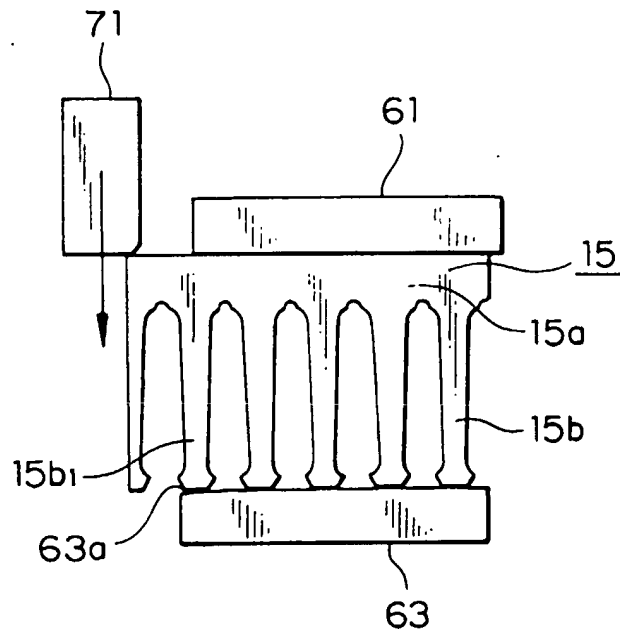


FIG. 10

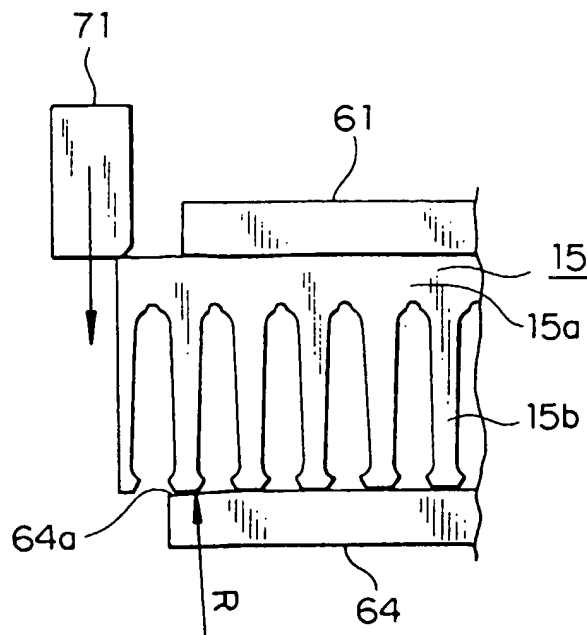


FIG. 11A FIG. 11B

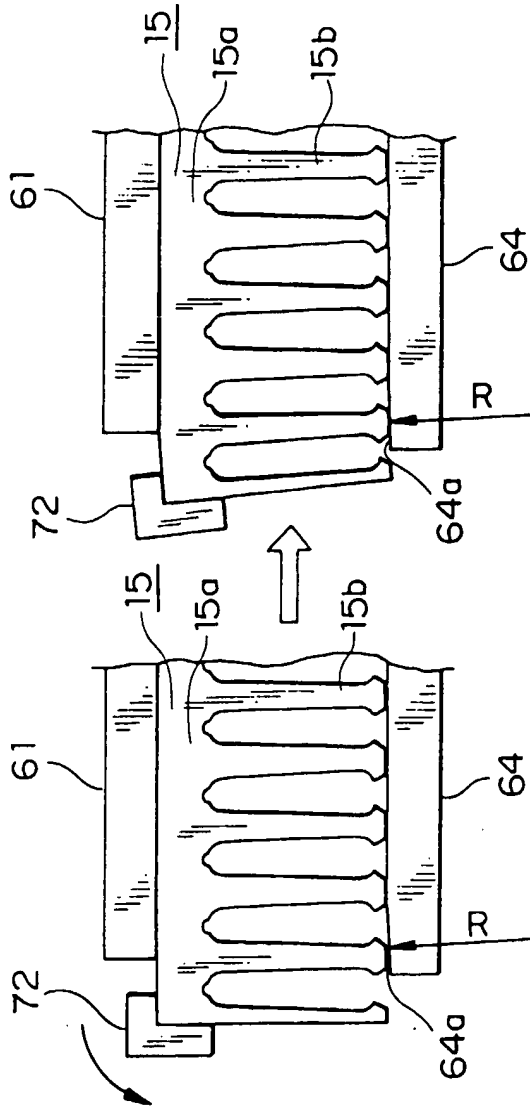


FIG. 12

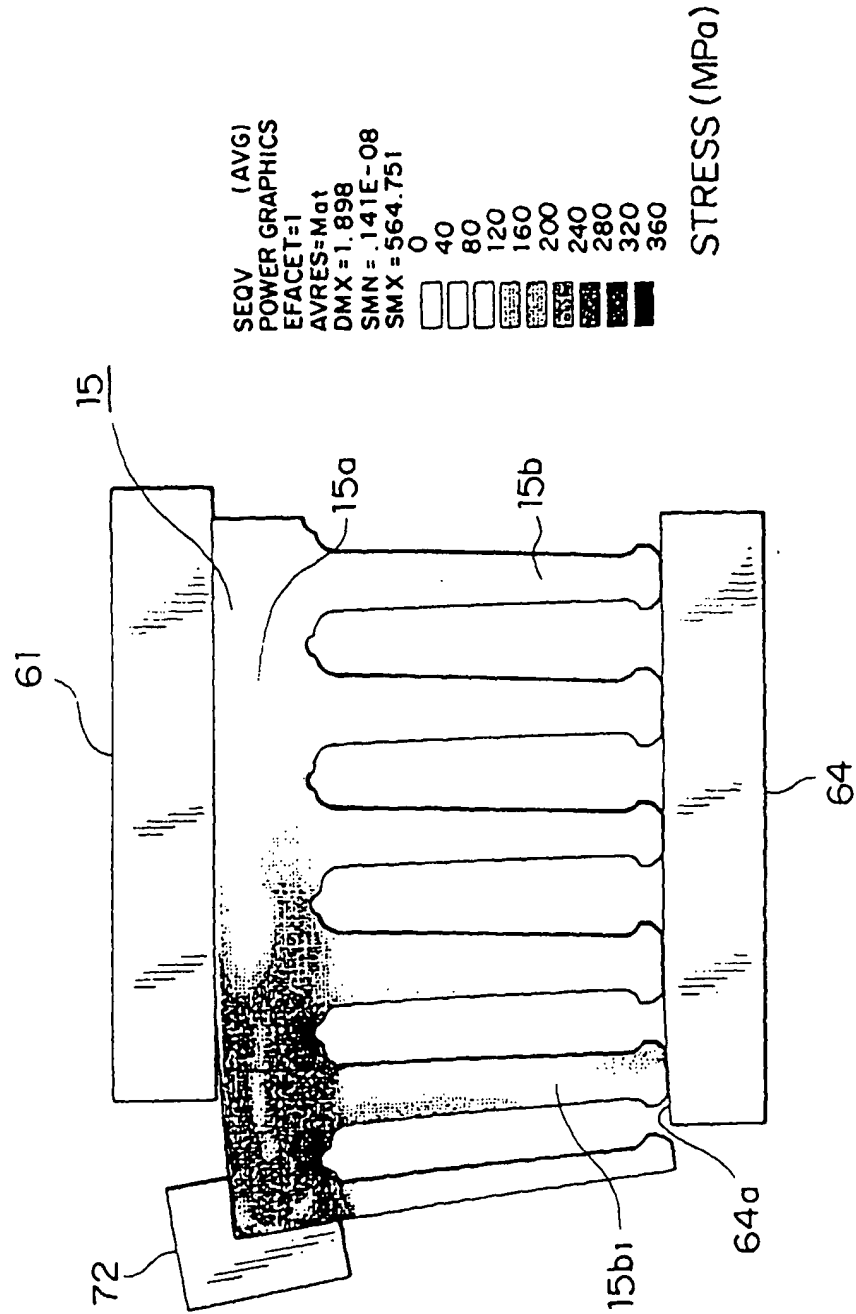


FIG. 13A

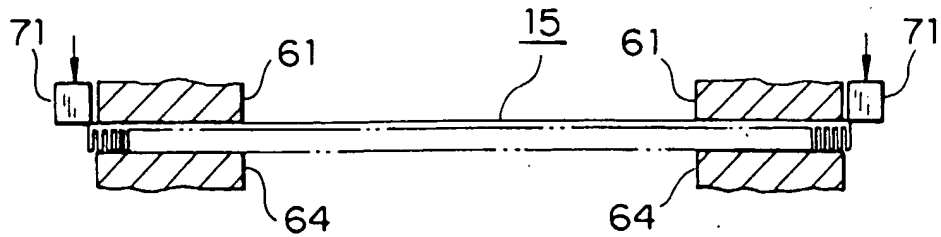


FIG. 13B

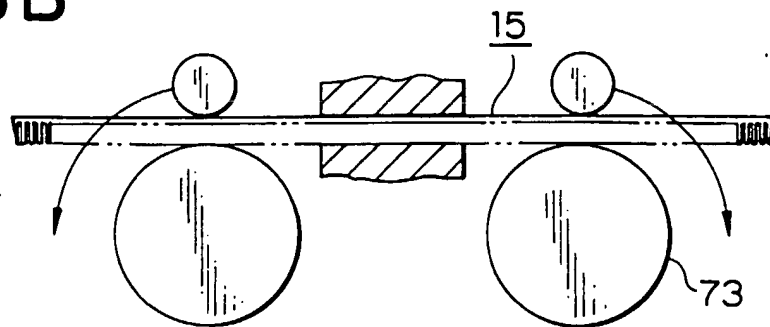


FIG. 13C

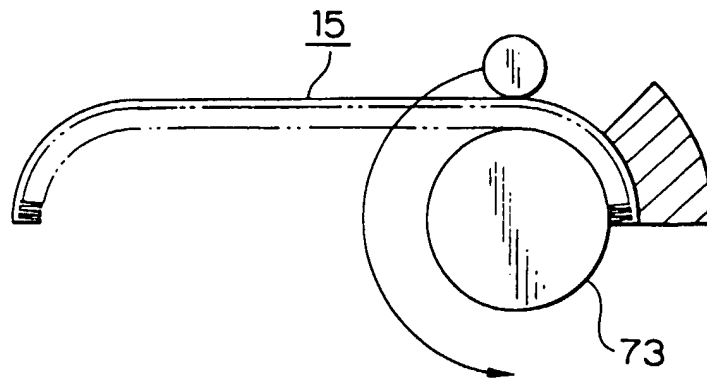


FIG. 13D

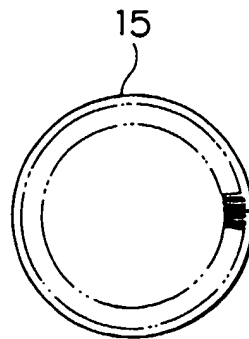


FIG. 14A

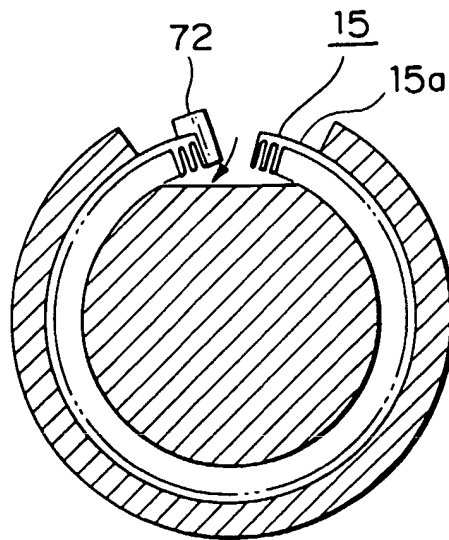


FIG. 14B

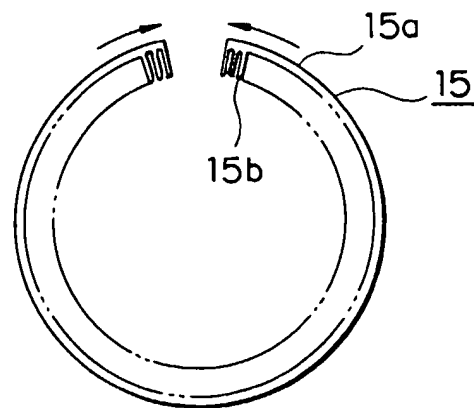


FIG. 14C

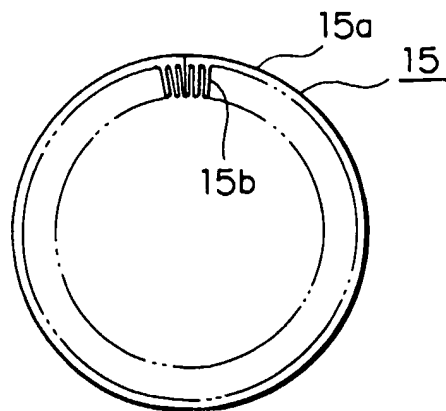


FIG. 15A

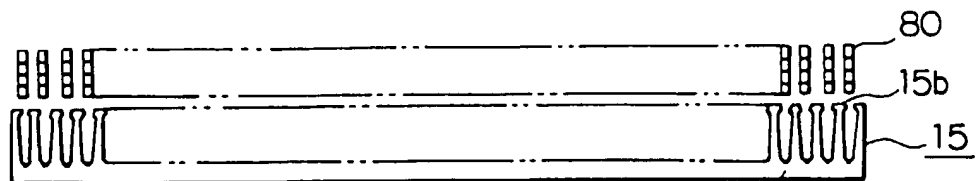


FIG. 15B

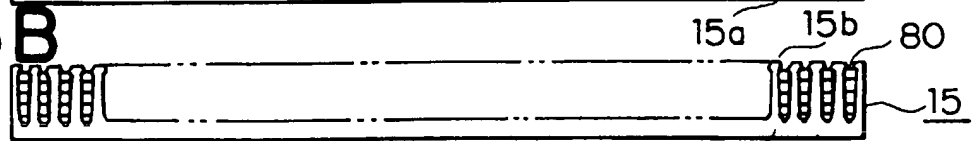


FIG. 15C

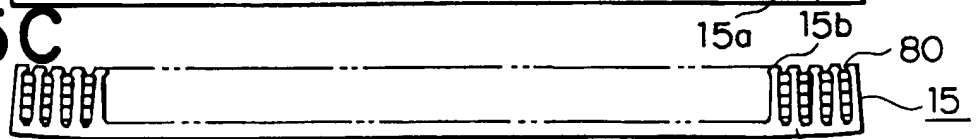


FIG. 15D

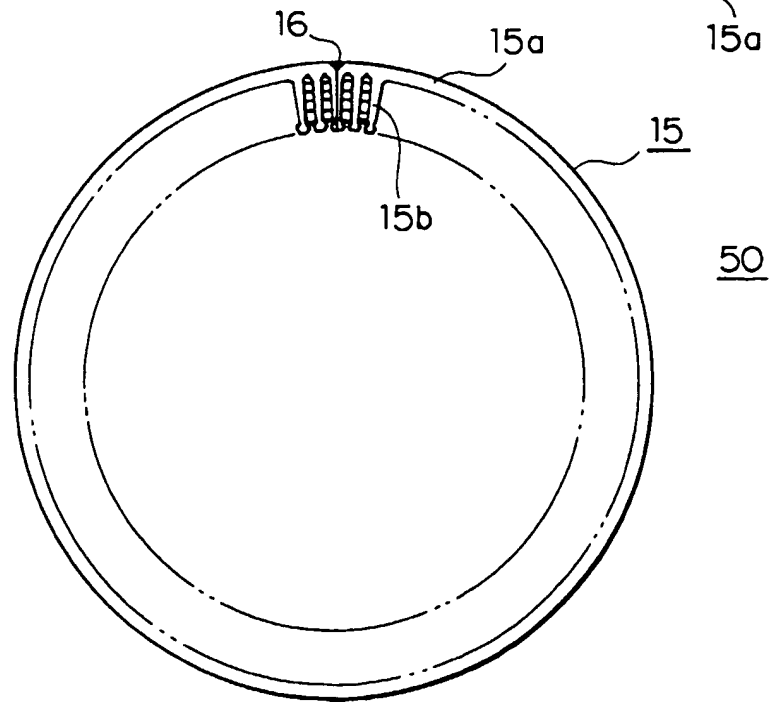


FIG. 16A

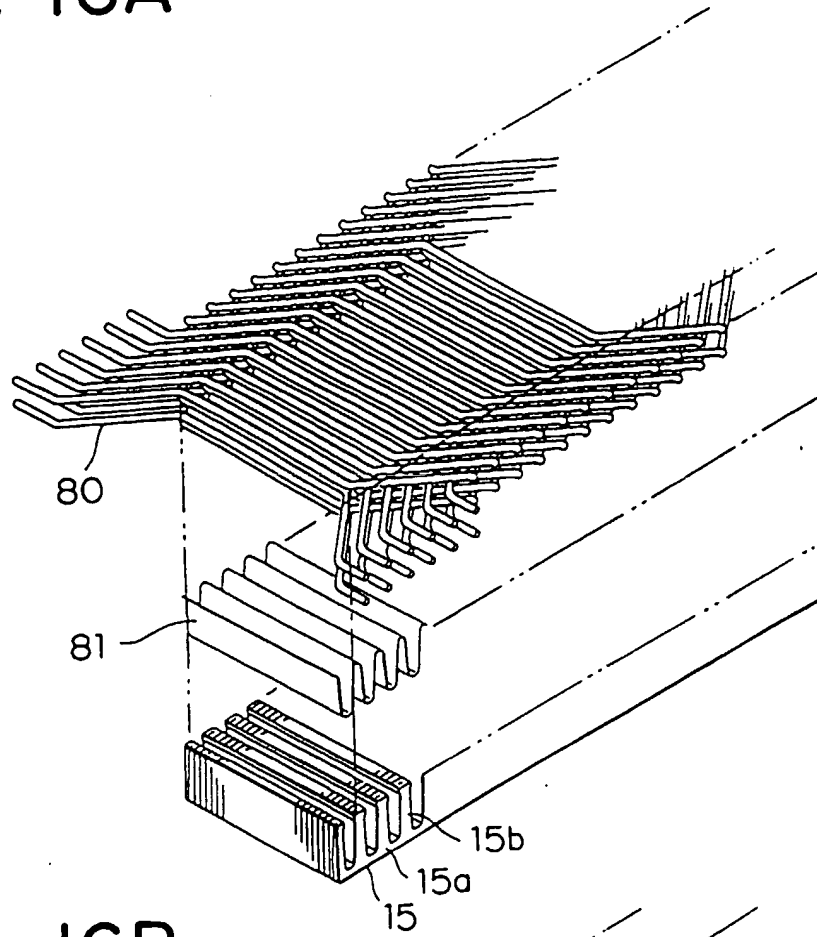


FIG. 16B

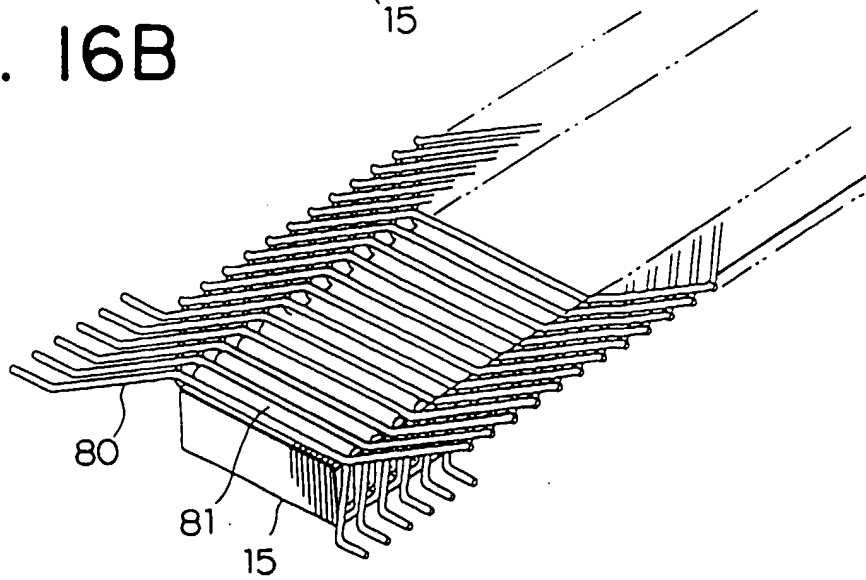


FIG. 17

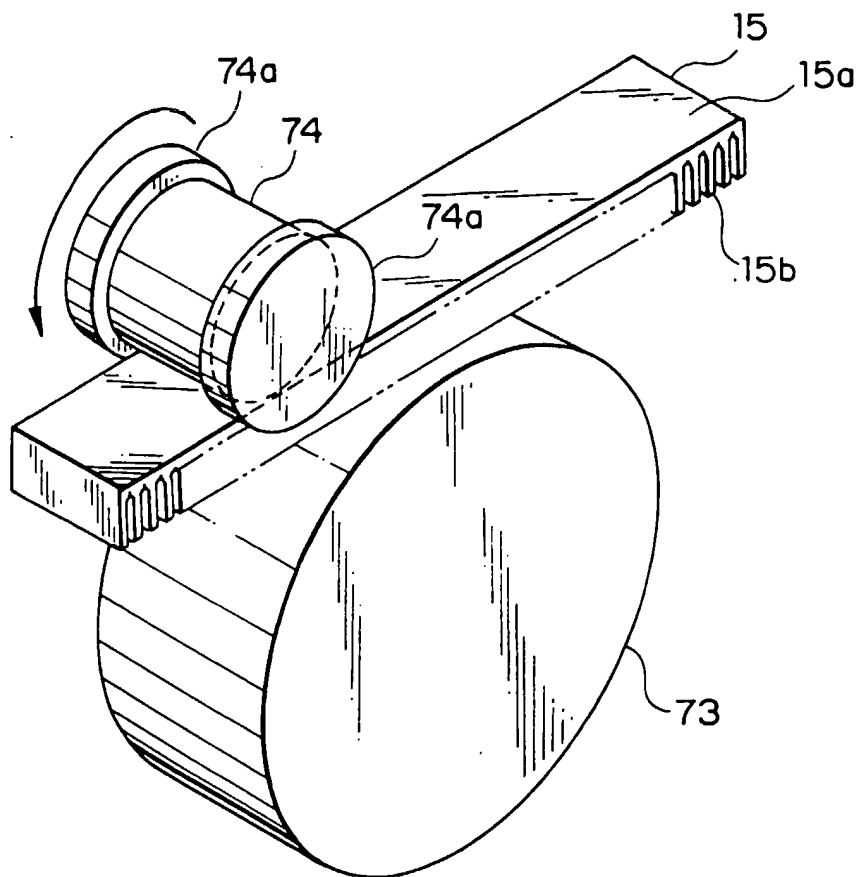


FIG. 18A

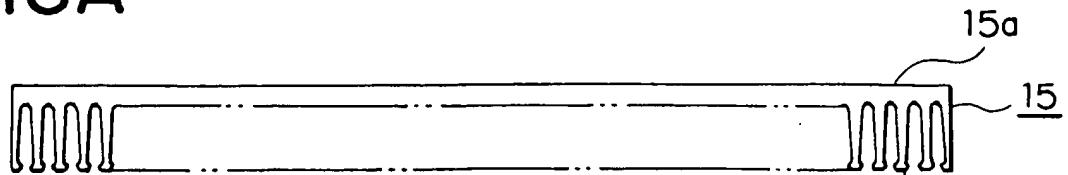


FIG. 18B

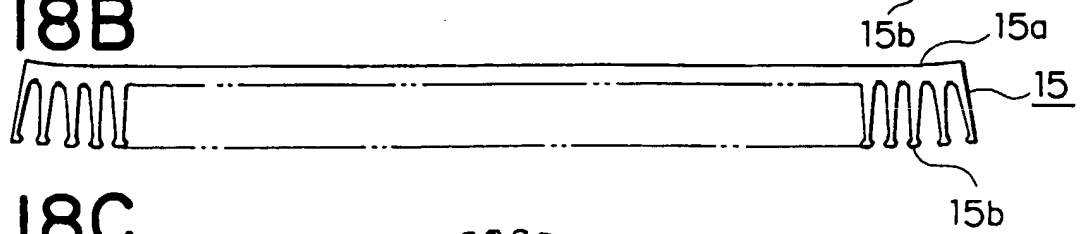


FIG. 18C

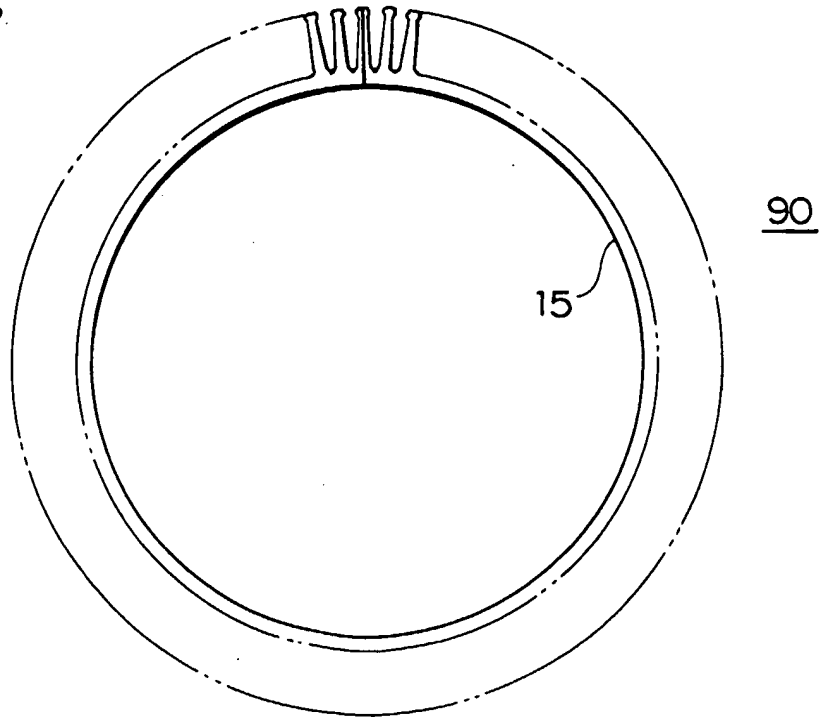


FIG. 19

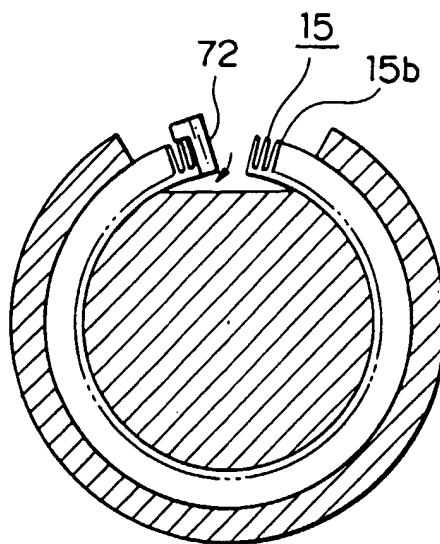


FIG. 20

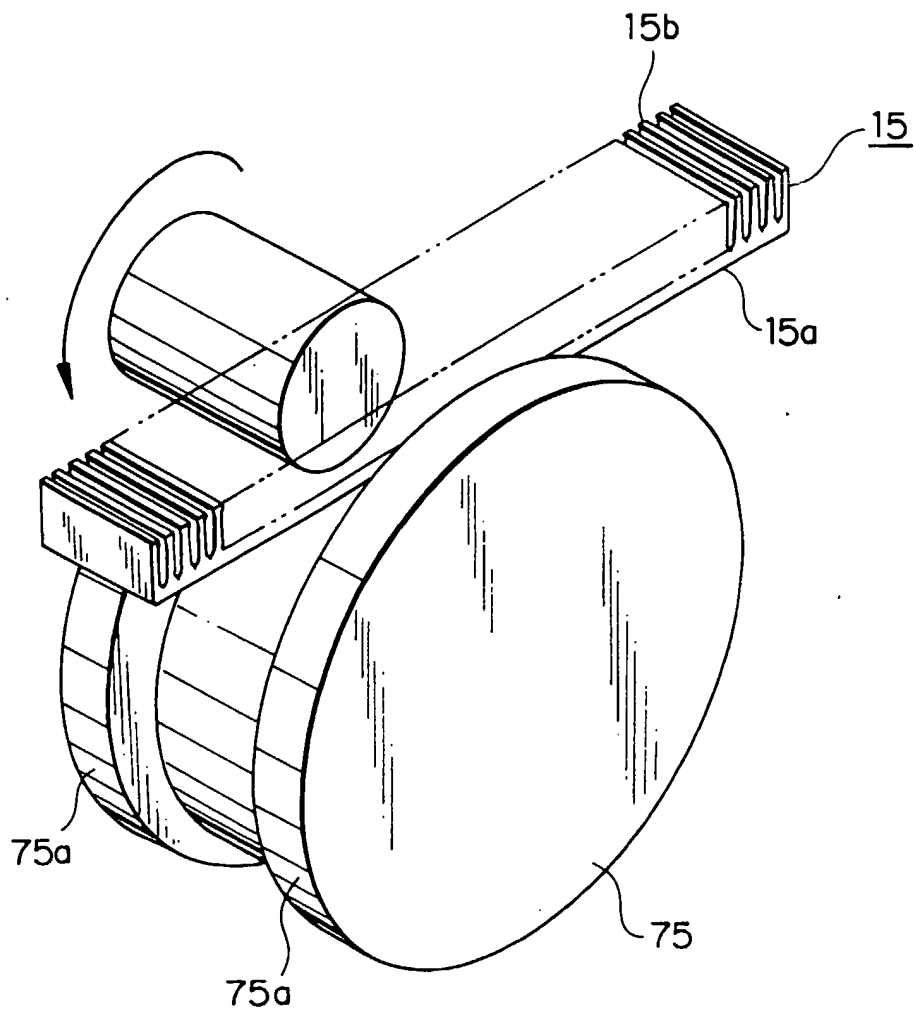


FIG. 21
PRIOR ART

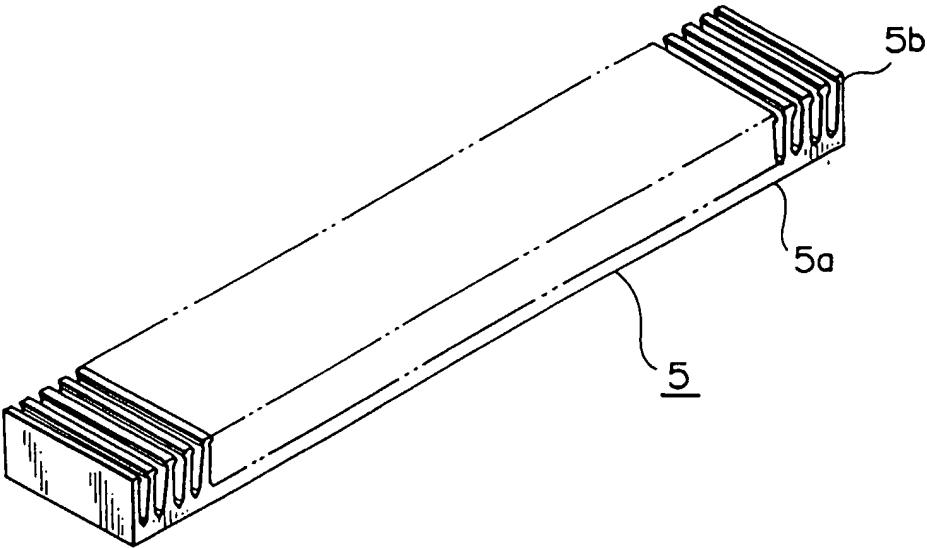


FIG. 22

PRIOR ART

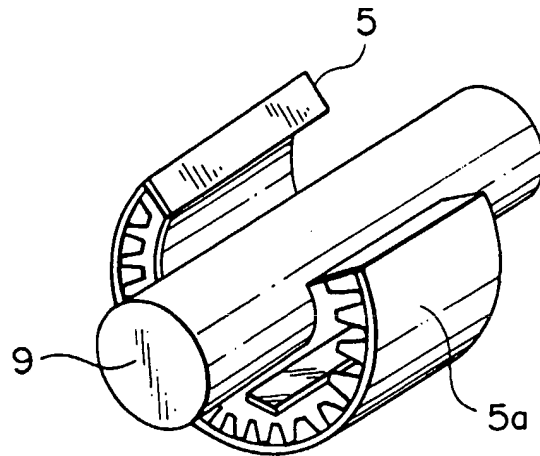


FIG. 23

PRIOR ART

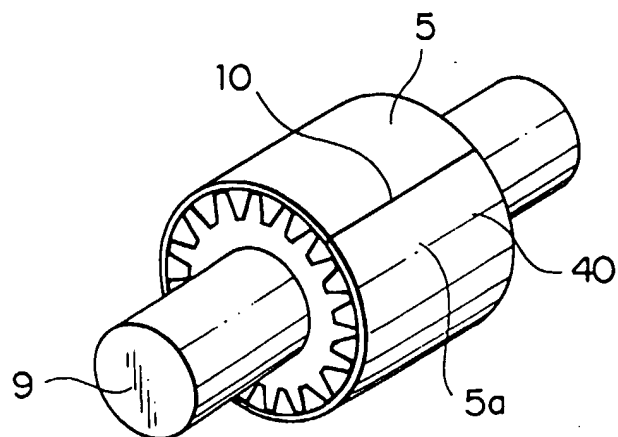
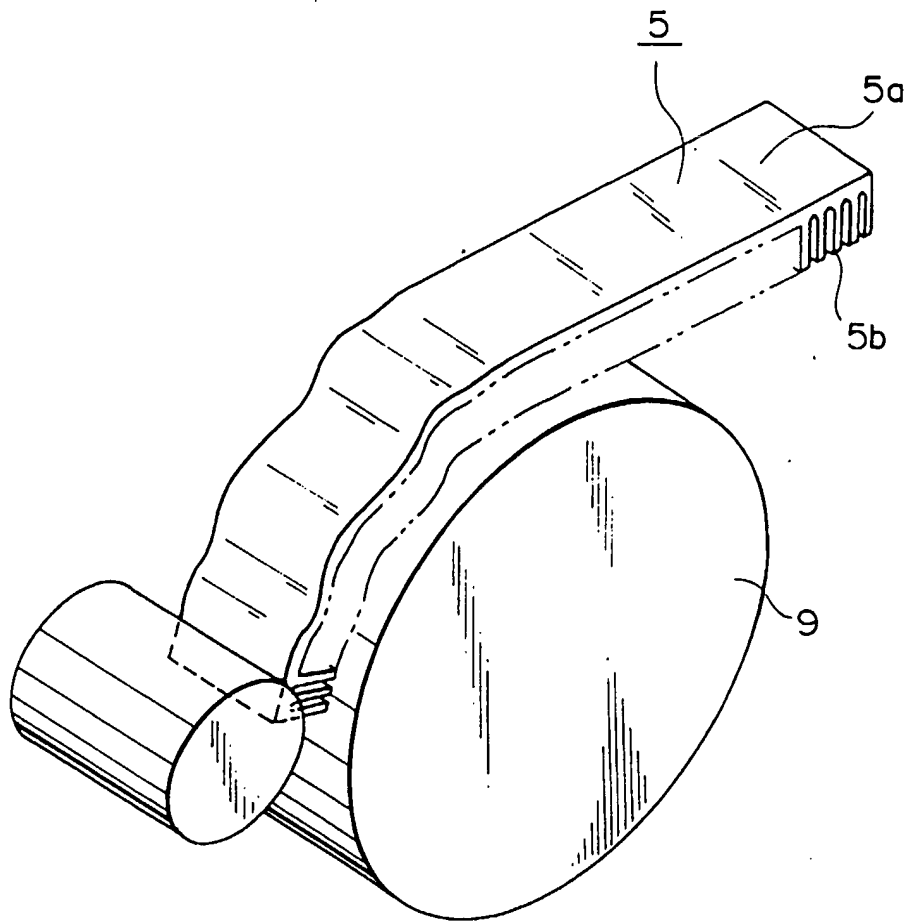


FIG. 24
PRIOR ART



(19)



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European Patent Office

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14.12.1999 JP 35519499
17.12.1999 JP 35888899
20.12.1999 JP 36128699
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20.01.2000 JP 2000011704
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(54) **Iron core of rotating-electric machine and manufacturing method for the same**

(57) An iron core of a rotating-electric machine and a manufacturing method for the same permit a uniform curvature to be easily obtained over an entire circumference of the iron core. The iron core has laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the core proximal portion, and slots for accommodating a winding that are located between the

teeth adjacent to each other. The iron core is fabricated by curving both end portions of a substantially hexahedral laminate so that the core proximal portion obtains a predetermined curvature, forming the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion, and joining both end portions of the laminate.

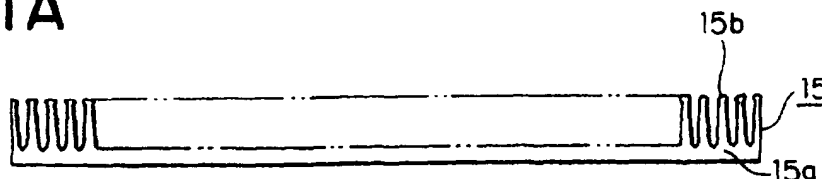
FIG. 1A

FIG. 1B

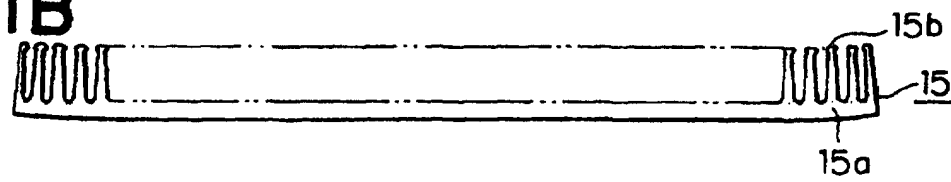
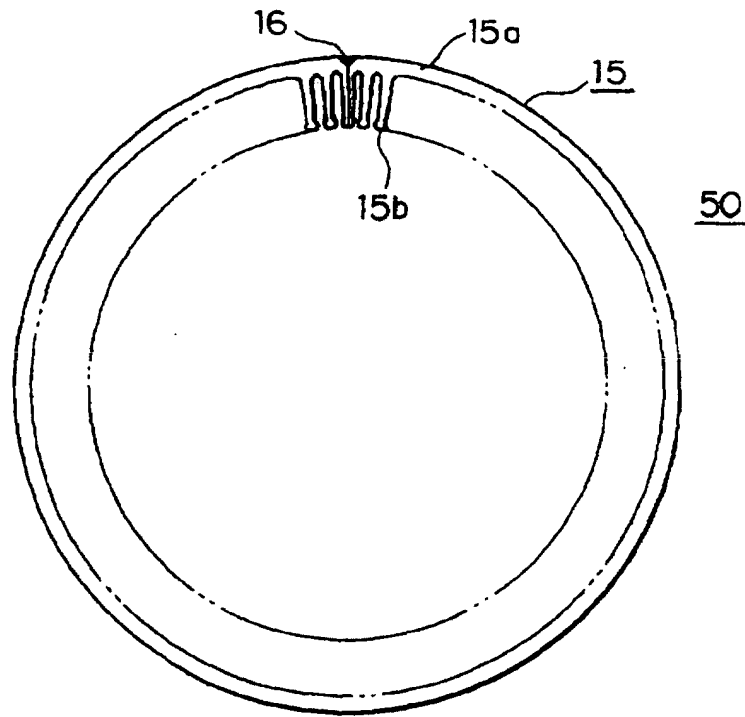


FIG. 1C





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 12 6506

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.7) |
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| A | DE 17 63 506 A (LICENTIA GMBH) 11 November 1971 (1971-11-11) * page 3, line 19 - page 4, line 18; figure 1 * | 1-10 | |
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| -/-- | | | |
| The present search report has been drawn up for all claims | | | |
| Place of search MUNICH | | Date of completion of the search 9 January 2002 | Examiner Tangocci, A |
| CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document | | T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document | |



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 12 6506

| DOCUMENTS CONSIDERED TO BE RELEVANT | | | |
|--|--|---|--|
| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int.Cl.7) |
| A | US 5 831 366 A (MCLEAN GRAHAM ET AL) 3 November 1998 (1998-11-03) * column 4, line 4 - line 28; figures 3-5 * | 1-10 | |
| | | | TECHNICAL FIELDS SEARCHED (Int.Cl.7) |
| | | | |
| The present search report has been drawn up for all claims | | | |
| Place of search MUNICH | | Date of completion of the search 9 January 2002 | Examiner Tangocci, A |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons A : member of the same patent family, corresponding document</p> | | | |

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 12 6506

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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09-01-2002

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(54) **Iron core of rotating-electric machine and manufacturing method for the same**

Eisenkern für rotierende elektrische Maschine und dessen Herstellungsverfahren

Noyau en fer pour machine électrique rotative et sa méthode de fabrication

(84) Designated Contracting States:
DE FR GB

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17.12.1999 JP 35888899
20.12.1999 JP 36128699
12.01.2000 JP 2000003621
25.01.2000 JP 2000015915
24.12.1999 JP 36753499
20.01.2000 JP 2000011680
20.01.2000 JP 2000011704
27.12.1999 JP 37025499
24.12.1999 JP 36845399
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- **Adachi, Katsumi**
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- **Asao, Yoshihito**
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- **Higashino, Kyoko**
Chiyoda-ku, Tokyo 100-8310 (JP)
- **Morishita, Akira**
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- **PATENT ABSTRACTS OF JAPAN vol. 017, no. 608 (E-1457), 9 November 1993 (1993-11-09) & JP 05 184105 A (KURODA PRECISION IND LTD), 23 July 1993 (1993-07-23)**
- **PATENT ABSTRACTS OF JAPAN vol. 1996, no. 07, 31 July 1996 (1996-07-31) & JP 08 080014 A (TOYOTA MOTOR CORP), 22 March 1996 (1996-03-22)**

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an iron core of a rotating-electric machine and, more particularly, to an iron core of a rotating-electric machine composed of laminated steel plates, and a manufacturing method for the same.

2. Description of the Related Art

[0002] Fig. 21 is a perspective view of a laminate used for an iron core of a conventional rotating-electric machine disclosed in, for example, Japanese Unexamined Patent Application Publication No. 48-9201. Fig. 22 shows a laminate of the iron core being formed by wrapping it around a cylindrical core member. Fig. 23 shows the formed iron core with its both end portions joined. A laminate 5 is fabricated by laminating a predetermined number of straight magnetic strips which are blanked out, and has a core proximal portion 5a and a plurality of teeth 5b equidistantly arranged. The laminate 5 that has been formed into a substantially hexahedral shape is wound with a winding (not shown), wrapped around a cylindrical core member 9 into a cylindrical shape, and an abutting portion 10 where both end portions thereof are abutted against each other is welded to join the end portions.

[0003] In the conventional iron core of a rotating-electric machine described above, as set forth above, a plurality of slots for accommodating the winding are formed in the magnetic strips, and the magnetic strips with the slots are stacked to form the substantially hexahedral laminate 5. The laminate 5 is wound around the cylindrical core member 9 to be shaped into a cylinder, and both end portions thereof are joined.

[0004] Such a conventional iron core 40 of a rotating-electric machine is not a cylindrical iron core from the start. Winding work can be facilitated by wrapping a winding (not shown) around the substantially hexahedral laminate 5. There is an advantage in that, since the laminated 5 is curved after installing the winding, a sectional area of a slot after curving becomes smaller than that before curving, thus allowing the winding to be disposed at a higher density.

[0005] On the other hand, in the case of the conventional iron core 40 of the rotating-electric machine having the construction described above, portions in the vicinity of both end portions are formed to have larger-radius curves than a curve of the remainder thereof, so that joining surfaces of the abutting end portions do not snugly meet, leading to unsuccessful joining when the virtually hexahedral laminate 5 is wrapped around the cylindrical core member into a cylindrical shape. More specifically, the curves near the abutting portion 10 are

insufficient, and a curvature radius is uneven over an entire circumference, presenting a problem in that joining surfaces are misaligned, resulting in unsuccessful joining.

[0006] There has been another problem in that forcibly meeting the abutting portion 10 deteriorates the roundness of the iron core.

[0007] Furthermore, in the conventional iron core 40 of a rotating-electric machine having the above construction, there has been still another problem in that wavy deformation as shown in Fig. 24 occurs when the iron core 40 is cylindrically wound around the cylindrical core member 9.

[0008] There has been yet another problem in that bending rigidity at both end portions of the virtually hexahedral laminate 5 is high, and a large force is required for curving the end portions, causing a tooth portion 5b to buckle.

SUMMARY OF THE INVENTION

[0009] Accordingly, the present invention has been made with a view toward solving the problems described above, and it is an object thereof to provide an iron core of a rotating-electric machine capable of allowing a curvature of the iron core to be easily made uniform over its entire circumference, permitting roundness of the cylindrical iron core to be improved, preventing the occurrence of wavy deformation and also preventing a tooth portion from buckling or deforming, allowing a reduced space between a magnetic pole or a magnet opposing the iron core to be achieved, allowing lower magnetic resistance of an air gap, and permitting an output of the rotating-electric machine to be increased. Another object of the present invention is to provide a manufacturing method for the iron core of the rotating-electric machine described above.

[0010] To this end, according to one aspect of the present invention, there is provided an iron core according to independent claim 1.

[0011] In a preferred form, both end portions of the core proximal portion of the laminate are provided with thinner portions that are thinner in a radial direction so as to have a lower rigidity.

[0012] In yet another preferred form, a filling member for making a diameter of a circumferential end portion of the core proximal portion identical to that of the remainder is welded to the thinner portions.

[0013] In still another preferred form, both end portions of the core proximal portion of the laminate are formed so that the diameter of the circumferential end portion of the core proximal portion becomes smaller toward and end thereof so as to reduce the rigidity thereof.

[0014] In a further preferred form, both end portions of the core proximal portion of the laminate are provided with at least one notch each at a location adjacent to the circumferential end portion of the core proximal portion so as to reduce the rigidity thereof.

[0015] In a further preferred form, the iron core of the rotating-electric machine is formed by curving a single virtually hexahedral laminate.

[0016] According to another aspect of the present invention, there is provided a manufacturing method according to independent claim 4.

[0017] In a preferred form, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and the end portions of the laminate are curved by pressing the end portions in a direction in which the teeth project by a pressing jig in the end portion curving step, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth toward an end thereof.

[0018] In another preferred form, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and a closely contacting jig having an L-shaped section is placed in close contact with a corner of the core proximal portion of the end of the laminate, and the end portions of the laminate are curved using the closely contacting jig such that they are wrapped toward the teeth, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth toward an end thereof.

[0019] In a further preferred form, the iron core is formed by curving a single laminate having a substantially hexahedral shape, and the body curving step includes: a first body curving step in which a central portion of the laminate is clamped, and both end portions of a predetermined length from ends are wrapped around a cylindrical core member; and a second body curving step in which the curved portions that have been formed in the first step are clamped and the remaining central portion is curved by wrapping it around the core member.

[0020] According to still another aspect of the present invention, there is provided a manufacturing method for an iron core of a rotating-electric machine according to independent claim 8.

[0021] In a preferred form, the manufacturing method includes a step for accommodating a winding in slots of the substantially hexahedral laminate before at least the body curving step, and the body curving step is implemented with the winding accommodated in the slots.

[0022] In a further preferred form, the body curving step is carried out while at least a part of the core proximal portion of the laminate is slidably guided from both sides.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Fig. 1 illustrates a manufacturing process of an iron core of a rotating-electric machine in accordance with the present invention, wherein Fig. 1A is a side view of a substantially hexahedral laminate, Fig. 1B is a side view of the laminate with its both end portions curved, and Fig. 1C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

Fig. 2 is a side view of an essential section showing another embodiment of the iron core of a rotating-electric machine in accordance with the present invention.

Fig. 3 presents side views of an essential section showing yet another embodiment of the iron core of the rotating-electric machine in accordance with the present invention, wherein Fig. 3A is a side view showing a recessed section in the vicinity of a junction, the recessed section being in the process of filling, and Fig. 3B is a side view showing the recessed section in the vicinity of the junction, the recessed section having been filled.

Fig. 4 is a side view showing an essential section of a further embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

Fig. 5 is a side view showing an essential section of a still another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

Fig. 6 is a side view showing an essential section of yet another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

Fig. 7 is a side view showing a state wherein an end of the substantially hexahedral laminate is being curved in an end portion curving step.

Fig. 8 is a diagram showing a distribution of internal stress generated when the end portion is curved by the method illustrated in Fig. 7.

Fig. 9 is a side view showing an end of a laminate being curved according to a manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention.

Fig. 10 is a side view showing an end of a laminate being curved according to another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention.

Fig. 11 is a process diagram showing an end of a laminate being curved according to yet another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention.

Fig. 12 is a diagram showing a distribution of inter-

nal stress generated when the end portion is curved by the method illustrated in Fig. 11.

Fig. 13 is a process diagram showing a procedure for curving a laminate according to still another embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

Fig. 14 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

Fig. 15 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

Fig. 16 is a diagram showing further details of the step for accommodating a winding shown in Fig. 15A.

Fig. 17 is a perspective view illustrating how the laminate is curved according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

Fig. 18 illustrates a manufacturing process of another embodiment of an iron core of a rotating-electric machine in accordance with the present invention, wherein Fig. 18A is a side view of a substantially hexahedral laminate, Fig. 18B is a side view of the laminate with its both end portions curved, and Fig. 18C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

Fig. 19 is a process diagram showing how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

Fig. 20 is a perspective view illustrating how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

Fig. 21 is a perspective view of a substantially hexahedral laminate constituting a conventional iron core of a rotating-electric machine.

Fig. 22 is a diagram showing an iron core composed of the laminate being formed by wrapping it around a cylindrical core member.

Fig. 23 is a diagram showing both end portions of the cylindrically formed iron core being joined.

Fig. 24 is a perspective view showing wavy deformation of an iron core observed when a laminate is curved.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

[0024] Fig. 1 is a diagram showing a manufacturing process of an iron core of a rotating-electric machine in accordance with the present invention. Fig. 1A is a side view of a substantially hexahedral laminate, Fig. 1B is a side view of the laminate with its both end portions curved, and Fig. 1C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

[0025] To fabricate a laminate 15, first, a plurality of linear magnetic strips, each having a core proximal portion 15a and a plurality of teeth 15b, are prepared by blanking out as in the case of the prior art, and the magnetic strips are laminated to fabricate the substantially hexahedral laminate 15 as shown in Fig. 1A.

[0026] Then, both end portions of the virtually hexahedral laminate 15 are curved at a predetermined curvature so that distal ends of the teeth 15b are oriented toward a center as shown in Fig. 1B (an end portion curving step). The predetermined curvature in this case is approximate to a curvature of a finished cylindrical iron core 50 or an iron core after curving the body of the laminate.

[0027] Lastly, as illustrated in Fig. 1C, the entire laminate 15 is cylindrically formed by wrapping it around a cylindrical core member (not shown) such that the distal ends of the teeth 15b are oriented to an inner periphery (a body curving step), and a joining portion 16 where both end portions of the laminate 15 abut against each other is welded by laser welding or electron beam welding (a joining step).

[0028] Lastly, the laminate 15 is formed into an iron core 50 that has the cylindrical core proximal portion 15a and the plural teeth 15b jutting out toward an axial center from the core proximal portion 15a, and is provided with slots for accommodating a winding, the slots being located between adjacent teeth.

[0029] In the iron core 50 of a rotating-electric machine constructed as described above, the end portions of the virtually hexahedral laminate 15 are curved in the end portion curving step, then the laminate 15 is formed into a cylindrical shape by wrapping the laminate 15 around a cylindrical core member in the body curving step. This arrangement permits an iron core to have uniform curvature over its entire circumference with consequent improved roundness of the cylindrical iron core 50. The improved roundness of the iron core 50 makes it possible to reduce a gap relative to a magnetic member disposed, facing against the iron core 50, permitting magnetic resistance in the gap to be reduced. Hence, an output of the rotating-electric machine can be improved.

Second Embodiment

[0030] Fig. 2 is a side view of an essential section illustrating another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0031] In a laminate 115 in this embodiment, portions on the outer periphery side of both end portions of the core proximal portion 15a are cut off, and a thinner portion 15c having a smaller thickness to reduce an outside diameter of the core proximal portion 15a is provided. This reduces the rigidity of both end portions. Fig. 2 shows only one end, whereas the thinner portion 15c is provided on both end portions of the laminate 115. The rest of the construction of this embodiment is identical to the construction of the first embodiment.

[0032] In the iron core of the rotating-electric machine configured as set forth above, the thinner portions 15c provided on both end portions of the substantially hexahedral laminate 115 permit the end portions to be curved more easily, and a force required for curving the end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of the teeth 15b.

Third Embodiment

[0033] Fig. 3 presents side views of an essential section showing yet another embodiment of the iron core of the rotating-electric machine in accordance with the present invention. Fig. 3A is a side view showing a recessed section in the vicinity of a junction, the recessed section being in the process of filling, and Fig. 3B is a side view showing the recessed section in the vicinity of the junction, the recessed section having been filled.

[0034] In the laminate 115 of the second embodiment described above, the portions on the outer periphery side of both end portions of a core proximal portion 15a are cut off, and the thinner portions 15c having a smaller thickness to reduce the outside diameter of the proximal portion 15a are provided on the end portions so as to lessen the rigidity of the end portions.

[0035] In an iron core 50 fabricated as described above, both end portions of the laminate 115 are joined in a joining step, then the recessed sections are formed in the vicinity of the junction on the outer periphery side. In general, when the proximal portion 15a of the iron core has a portion having a smaller radial width, magnetic saturation occurs due to the portion, resulting in a lower output of the rotating-electric machine.

[0036] In the third embodiment, to solve the problem mentioned above, a filling piece 17 for filling the thinner portions 15c forming the recessed section is welded so as to make the outside diameter of the thinner portions 15c identical to the remainder. The filling piece has a configuration that snugly fits in the recessed section, and is welded at both end portions (junctions 16b and 16c) by laser welding or electron beam welding.

[0037] The rest of the construction of the third embodiment is the same as the construction of the second embodiment.

[0038] In the iron core 50 of the rotating-electric machine configured as set forth above, the core proximal portion 15a has no portion of a smaller radial width, so that likelihood of the occurrence of magnetic saturation is reduced, leading to higher output of the rotating-electric machine. Furthermore, welding the filling piece 17 improves the strength of the iron core.

Fourth Embodiment

[0039] Fig. 4 is a side view showing an essential section of a further embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0040] In a laminate 215 of this embodiment, slope portions 15d are formed on both end portions of a core proximal portion 15a so that an outside diameter of the proximal portion grows smaller toward the end portions, thus reducing the rigidity thereof.

[0041] The rest of the construction of the fourth embodiment is the same as that of the first embodiment.

[0042] In an iron core 50 of the rotating-electric machine configured as set forth above, both end portions of the substantially hexahedral laminate 215 permits both end portions to be curved easily, and a force required for curving both end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of teeth 15b. Moreover, the simple configuration permits easy machining of the end portions.

Fifth Embodiment

[0043] Fig. 5 is a side view showing an essential section of a still another embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0044] In a laminate 315 of this embodiment, both end portions of a core proximal portion 15a are provided with notches 15e, whose sections are shaped like narrow slots, at the outer periphery side thereof so as to reduce the rigidity.

[0045] The rest of the configuration is the same as the configuration of the first embodiment.

[0046] In an iron core 50 of the rotating-electric machine configured as described above, both end portions of the substantially hexahedral laminate 315 can be curved easily, and a force required for curving both end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of teeth 15b. Moreover, the simple configuration permits easy machining of the end portions.

Sixth Embodiment

[0047] Fig. 6 is a side view showing an essential section of a further embodiment of the iron core of the rotating-electric machine in accordance with the present invention.

[0048] In a laminate 415 of this embodiment, both end portions of a core proximal portion 15a are provided with notches 15f, whose sections are triangular, at the outer periphery side thereof so as to reduce the rigidity.

[0049] The rest of the configuration is the same as the configuration of the first embodiment.

[0050] In an iron core 50 of the rotating-electric machine configured as described above, both end portions of the substantially hexahedral laminate 415 can be curved easily, and a force required for curving both end portions is reduced, making it possible to lessen possibilities of the occurrence of buckle or deformation of teeth 15b. Moreover, the simple configuration permits easy machining of the end portions.

Seventh Embodiment

[0051] Fig. 7 is a side view showing a state wherein an end of the substantially hexahedral laminate is being curved. Fig. 8 is a diagram showing a distribution of internal stress generated when the end portion is curved by the method illustrated in Fig. 7. In Fig. 8, a darker shade denotes an area to which a higher stress is applied.

[0052] In a method for curving the two end portions of a substantially hexahedral laminate 15 shown in Fig. 7, the laminate 15 is clamped by a first fixing jig 61 disposed on a core proximal portion 15a and a second fixing jig 62 disposed on teeth 15b so that end portions jut out by a predetermined length. A pressing jig 71 is abutted against the end of the core proximal portion 15a of the laminate 15, and the laminate 15 is pressed vertically or in the direction in which the teeth 15b project.

[0053] This method has been posing a problem in that a high stress is applied to a second tooth 15b1 from the end to be curved as shown in Fig. 8, causing the second tooth 15b1 to buckle.

[0054] Fig. 9 is a side view showing a step for curving the end of the laminate according to the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention. According to the manufacturing method for an iron core of this embodiment, the end of the second fixing jig 63 adjacent to the teeth 15b is provided with a linear slope 63a formed to be distanced farther from the teeth 15b toward the end in the vicinity of a location where the second tooth 15b1 from the end abuts the jig. This arrangement protects the second tooth 15b1 from the end to be curved from an excessive stress, thus preventing the second tooth 15b1 from buckling.

[0055] In the manufacturing method for an iron core of a rotating-electric machine described above, both end

portions of the laminate are curved to have a final curvature according to the above method before the entire laminate is formed into a cylindrical shape by wrapping it around a cylindrical core member. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of a cylindrical iron core 50. The improved roundness of the iron core 50 allows a reduced gap relative to a rotator opposing the iron core, and a magnetic resistance in the gap can be reduced. Hence, a higher output of the rotating-electric machine can be accomplished.

[0056] Moreover, the end portions can be curved simply by pressing them in the direction in which the teeth 15b project, permitting the machining procedure to be simplified. In addition, the slope 63a makes it possible to set the angle at which the teeth 15b abut the second fixing member 63 at an appropriate angle, lessening the possibility of buckle or deformation of the teeth 15b, which interfere with curving.

Eighth Embodiment

[0057] Fig. 10 is a side view showing an end of a laminate being curved according to another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention.

[0058] In the manufacturing method for the iron core of this embodiment, the end of a second fixing jig 64 adjacent to the teeth 15b is provided with an arc slope 64a formed to be distanced farther from the teeth 15b toward the end in the vicinity of a location where the second tooth 15b1 from the end abuts the jig.

[0059] The rest of the configuration of this embodiment is the same as the configuration of the seventh embodiment.

[0060] In the manufacturing method for the iron core of the rotating-electric machine described above, the arc slope 64a makes it possible to set the angle at which the teeth 15b abut the second fixing member 64 to a further appropriate angle, thus further lessening the possibility of buckle or deformation of the teeth 15b, which interfere with curving.

Ninth Embodiment

[0061] Fig. 11 is a process diagram showing an end of a laminate being curved according to yet another embodiment of the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention. Fig. 12 is a diagram showing a distribution of internal stress generated when the end portion is curved by the method illustrated in Fig. 11. In Fig. 12, a darker shade denotes an area to which a higher stress is applied.

[0062] In this embodiment, as in the case of the eighth embodiment, the end of a second fixing jig 64 adjacent

to the teeth 15b is provided with an arc slope 64a formed to be distanced farther from the teeth 15b toward the end in the vicinity of a location where the second tooth 15b1 from the end abuts the jig.

[0063] Further, in this embodiment, a closely contacting jig 72 having an L-shaped section is brought into close contact with a corner of the end of the core proximal portion 15a of the laminate 15 as shown in Fig. 11A, and the end portion of the laminate 15 is curved to wrap toward teeth 15b as shown in Fig. 11B by using the closely contacting jig 72.

[0064] In this embodiment, the slope 64a combined with the curving method using the closely contacting jig 72 for wrapping-like curving hardly apply a stress to the second tooth 15b1 as can be seen from Fig. 12.

[0065] In the manufacturing method for the iron core of the rotating-electric machine described above, the arc slope 64a makes it possible to set the angle at which the teeth 15b abut the second fixing member 64 to an appropriate angle, thus further lessening the possibility of buckle of the teeth 15b. Moreover, since the end portion is curved to wrap using the closely contacting jig 72, a curving moment can be applied to the portion of the laminate 15 to be curved while reducing the stress applied to the teeth 15b at a position away from the end by a predetermined distance. This makes it possible to further lessen the possibility of buckle of the teeth 15b.

Tenth Embodiment

[0066] Fig. 13 is a process diagram showing a procedure for curving a laminate according to still another embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0067] In this embodiment, as shown in Fig. 13A, both end portions of a laminate 15 are curved at a predetermined curvature so that distal ends of the teeth 15b are oriented toward a center according to the method of the eighth embodiment (an end portion curving step).

[0068] Then, as illustrated in Fig. 13B, a central portion of the laminate 15 is clamped, and both end portions, each having a quarter length from the end, are curved by being wrapped around cylindrical core members 73 (a first body curving step).

[0069] Next, as illustrated in Fig. 13C, one of the portions that have been curved by the quarter length in the first body curving step is held, and the remaining uncurved central portion is curved by being wrapped around the core member 73 (a second body curving step).

[0070] Lastly, as shown in Fig. 13D, both end portions of the laminate abutting each other are joined by laser welding or electron beam welding (a joining step).

[0071] According to the manufacturing method for the iron core of the rotating-electric machine described above, a wide area of the central portion is clamped, so that the end portions can be easily wound onto the core

members.

Eleventh Embodiment

5 [0072] Fig. 14 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

10 [0073] In this embodiment, end portions of a laminate 15 are not curved in a first step. According to the embodiment, the entire laminate 15 is curved according to the procedure illustrated in Fig. 13B and Fig. 13C of the tenth embodiment (a body curving step).

15 [0074] Then, as shown in Fig. 14A, the laminate 15, which has been curved in the foregoing body curving step, is clamped at its entire inner and outer peripheries except for its end portions. A closely contacting jig 72 having an L-shaped section is brought into close contact with a corner of an end of a core proximal portion 15a of the laminate 15, and the end portion of the laminate 15 is curved to wrap toward teeth 15b by using the closely contacting jig 72 (an end portion curving step).

20 [0075] Thereafter, as illustrated in Fig. 14B and Fig. 14C, both end portions of the laminate are abutted each other and joined by laser welding or electron beam welding (a joining step).

25 [0076] The manufacturing method for an iron core of a rotating-electric machine described above makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a rotator opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Furthermore, the laminate is held at inner and outer peripheries thereof other than the end portions when curving the end portions, thus ensuring firm support. Hence, the occurrence of buckle of teeth 15b can be further reduced.

Twelfth Embodiment

45 [0077] Fig. 15 is a process diagram showing a procedure for curving a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention. Fig. 16 is a diagram showing further details of a step for accommodating a winding shown in Fig. 15A.

50 [0078] This embodiment has a step for accommodating a winding 80 in slots of a substantially hexahedral laminate 15 (a winding accommodating step) as shown in Fig. 15A prior to the body curving step of the first embodiment. In the winding accommodating step, the winding 80 and an insulator 81, which is interposed between the winding 80 and the laminate 15, are accom-

modated in the slots as shown in Fig. 16.

[0079] Thereafter, in the same manner as that of the first embodiment, the body curving step and the joining step are implemented except that these two steps are carried out with the winding 80 accommodated in the slots.

[0080] The manufacturing method for an iron core of a rotating-electric machine described above makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a rotator opposing the iron core, and a magnetic resistance in the gap can be reduced, so that an output of a rotating-electric machine can be increased. Furthermore, the winding 80 is accommodated in the substantially hexahedral laminate 15, permitting an easy accommodating operation. In addition, sectional areas of the slots decrease after curving. Therefore, an occupancy of the winding in the slots can be increased, and the output of the rotating-electric machine can be improved.

[0081] The aforesaid winding accommodating step can be carried out before the body curving step in any one of the methods according to the first to eleventh embodiments. Subsequent steps can be carried out with the winding 80 accommodated in the slots.

Thirteenth Embodiment

[0082] Fig. 17 is a perspective view illustrating how the laminate is curved according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0083] In this embodiment, a body curving step is implemented using a slidable forming jig 74 for guiding on both side surfaces of a core proximal portion 15a of a laminate 15. Flanges 74a formed on both edges of the forming jig 74 abut both side surfaces of the core proximal portion 15a with slight clearances therebetween to perform guidance in a slidable state.

[0084] According to the manufacturing method for an iron core of a rotating-electric machine described above, the flanges 74a of the forming jig 74 guide the laminate 15 to prevent the laminate 15 from deforming in a direction of lamination. This arrangement allows the possibility of wavy deformation of the laminate 15 to be decreased.

[0085] The forming jig in this embodiment can be used for the body curving step in the first to twelfth embodiments.

Fourteenth Embodiment

[0086] Fig. 18 illustrates a manufacturing process of another embodiment of an iron core of a rotating-electric machine in accordance with the present invention. Fig.

18A is a side view of a substantially hexahedral laminate, Fig. 18B is a side view of the laminate with its both end portions curved, and Fig. 18C is a side view of the laminate with its both end portions joined to form a cylindrical iron core.

[0087] An iron core of a rotating-electric machine according to this embodiment is an iron core 90 employed with, for example, a rotor of a motor. The iron core 90 is composed of laminated magnetic strips, and has a cylindrical core proximal portion 15a, a plurality of teeth 15b radially projecting outward from the core proximal portion 15a, and slots formed between adjacent teeth 15b to accommodate a winding.

[0088] To fabricate a laminate 15, first, a plurality of linear magnetic strips, each having a core proximal portion 15a, and a plurality of teeth 15b are prepared by blanking out as in the case of the prior art, and the magnetic strips are laminated to fabricate the substantially hexahedral laminate 15 as shown in Fig. 18A.

[0089] Then, both end portions of the virtually hexahedral laminate 15 are curved at a predetermined curvature so that distal ends of the teeth 15b are radially spread at predetermined intervals as shown in Fig. 18B (an end portion curving step). The predetermined curvature in this case is approximate to a curvature of a finished cylindrical iron core 90 or an iron core after curving the body of the laminate.

[0090] Lastly, as illustrated in Fig. 18C, the entire laminate 15 is cylindrically formed by wrapping it around a cylindrical core member (not shown) such that the distal ends of the teeth 15b are oriented to an outer periphery (a body curving step), and a joining portion where both end portions of the laminate 15 abut against each other is welded by laser welding or electron beam welding (a joining step).

[0091] In the iron core 90 of a rotating-electric machine constructed as described above, the end portions of the virtually hexahedral laminate 15 are curved in the end portion curving step, then the laminate 15 is formed into a cylindrical shape by wrapping the laminate 15 around a cylindrical core member in the body curving step. This arrangement permits an iron core to have a uniform curvature over its entire circumference with consequent improved roundness of the cylindrical iron core 90. The improved roundness of the iron core 90 makes it possible to reduce a gap relative to a magnetic pole or a magnet disposed, facing against the iron core 90, permitting magnetic resistance in the gap to be reduced. Hence, an output of the rotating-electric machine can be improved.

Fifteenth Embodiment

[0092] Fig. 19 is a process diagram showing how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0093] According to this embodiment, a fabricating method associated with the eleventh embodiment is applied to fabricate the iron core 90 in the fourteenth embodiment. In this embodiment, end portions of a laminate 15 are not curved in a first step. In the embodiment, the entire laminate 15 is curved according to the procedure illustrated in Fig. 13B and Fig. 13C of the tenth embodiment (a body curving step).

[0094] Thereafter, as illustrated in Fig. 19, the laminate 15 that has been curved in the foregoing body curving step is clamped at entire inner and outer peripheries thereof except for end portions. Then, a closely contacting jig 72 having an L-shaped section is brought into close contact with a corner of the end of teeth 15b of the laminate 15, and the end of the laminate 15 is curved to wrap toward a core proximal portion 15a by the closely contacting jig 72 (an end portion curving step).

[0095] The manufacturing method for an iron core of a rotating-electric machine described above makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Furthermore, the laminate is held at inner and outer peripheries thereof other than the end portions when curving the end portions, thus ensuring firm support. Hence, the occurrence of buckle of teeth 15b can be further reduced.

Sixteenth Embodiment

[0096] Fig. 20 is a perspective view illustrating how to curve a laminate according to a further embodiment of the manufacturing method of the iron core of a rotating-electric machine in accordance with the present invention.

[0097] According to this embodiment, a fabricating method associated with the thirteenth embodiment is applied to fabricate the iron core 90 in the fourteenth embodiment.

[0098] In this embodiment, a body curving step is implemented using a slidable forming jig 75 for guiding on both side surfaces of a core proximal portion 15a of a laminate 15. Flanges 75a formed on both edges of the forming jig 75 abut both side surfaces of the core proximal portion 15a with slight clearances therebetween to perform guidance in a slidable state.

[0099] According to the manufacturing method for an iron core of a rotating-electric machine described above, the flanges 75a of the forming jig 75 guide the laminate 15 to prevent the laminate 15 from deforming in a direction of lamination. This arrangement allows wavy deformation of the laminate 15 to be controlled.

[0100] As described above, an iron core of a rotating-electric machine in accordance with the present inven-

tion is constructed by laminated magnetic strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the core proximal portion, and slots for accommodating a winding that are located between the teeth adjacent to each other, wherein the iron core is fabricated by curving both end portions of a substantially hexahedral laminate so that the core proximal portion obtains a predetermined curvature, forming the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion, and joining both end portions of the laminate. Thus, both end portions of the laminate are curved to obtain a final curvature before the entire laminate is formed into a cylindrical shape by wrapping it around the cylindrical core member. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of a cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap is reduced. Hence, a higher output of the rotating-electric machine can be accomplished.

[0101] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate have a lower rigidity than that of the remainder thereof. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, requiring a less force for curving the two end portions, and a uniform curvature of the iron core can be easily accomplished, permitting further improved roundness of the cylindrical iron core.

[0102] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate are provided with portions that are thinner in a radial direction so as to have a lower rigidity. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, requiring a less force for curving the two end portions, and a uniform curvature of the iron core can be easily accomplished, permitting further improved roundness of the cylindrical iron core.

[0103] In the iron core of a rotating-electric machine in accordance with the present invention, a filling member for filling the thinner portion for making a diameter of a circumferential end of the core proximal end identical to that of the remainder of the iron core is welded to the thinner portion. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, requiring a less force for curving the two end portions, and a uniform curvature of the iron core can be easily accomplished, permitting further improved roundness of the cylindrical iron core. Moreover, the core proximal portion has no portion of a smaller radial width since the portion recessed in the radial direction is filled with the filling piece, so that likelihood of the oc-

currence of magnetic saturation is reduced, leading to higher output of the rotating-electric machine. In addition, welding the filling piece improves the strength of the iron core.

[0104] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate are formed so that the diameter of the circumferential end portions of the core proximal end become smaller toward their ends so as to reduce rigidity. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, so that the force required for curving both end portions is reduced, and a uniform curvature of the iron core can be easily achieved, permitting further improved roundness of the cylindrical iron core. Moreover, the simple configuration of both end portions of the iron core permits easy machining of the end portions.

[0105] In the iron core of a rotating-electric machine in accordance with the present invention, both end portions of the core proximal portion of the laminate are provided with at least one notch each at the circumferential end portions of the core proximal portion so as to reduce the rigidity thereof. With this arrangement, both end portions of the substantially hexahedral laminate can be easily curved, so that the force required for curving both end portions is reduced, and a uniform curvature of the iron core can be easily achieved, permitting further improved roundness of the cylindrical iron core. Moreover, the simple configuration for reducing the rigidity permits easy machining of the end portions.

[0106] The iron core of a rotating-electric machine in accordance with the present invention is formed by curving a single virtually hexahedral laminate. Thus, a single substantially hexahedral laminate is used, so that only one joining step is required. Moreover, since there are fewer joining places, the strength of the iron core can be improved.

[0107] The manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the iron core including laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the proximal portion, and slots located between adjoining teeth to accommodate a winding, includes: an end portion curving step for curving both end portions of a substantially hexahedral laminate of the iron core so that the core proximal portion has a predetermined curvature, a body curving step for curving the entire laminate into a cylindrical shape by wrapping it around a cylindrical core member so that distal ends of the teeth project from the core proximal portion, and a joining step for joining both end portions of the laminate. Hence, both end portions of the laminate are curved to have a final curvature before the entire laminate is wrapped around the cylindrical core member so as to be formed into the cylindrical shape. This makes it possible to easily provide the iron core with a uniform cur-

vature over the entire circumference thereof, resulting in improved roundness of a cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap is reduced. Hence, a higher output of the rotating-electric machine can be accomplished.

[0108] According to the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and the end portions of the laminate are curved by pressing the end portions in a direction in which the teeth project by a pressing jig in the end portion curving step, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth toward an end thereof. Hence, the end portions can be curved simply by pressing them in the direction in which the teeth project, permitting the machining procedure to be simplified. In addition, the slope makes it possible to set the angle, at which the teeth abut the second fixing member, to an appropriate angle, lessening the possibility of buckle of the teeth.

[0109] According to the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the laminate is clamped between a first fixing jig disposed at the core proximal portion and a second fixing jig disposed at the teeth such that the end portions project by a predetermined length, and a closely contacting jig having an L-shaped section is placed in close contact with a corner on the core proximal portion of the end of the laminate, and the end portions of the laminate are curved using the closely contacting jig such that they are wrapped toward the teeth, an end portion of the second fixing jig that is adjacent to the teeth being provided with an arc or linear slope that becomes farther from the teeth toward an end thereof. Therefore, the slope makes it possible to set the angle, at which the teeth abut the second fixing member, to an appropriate angle, thus lessening the possibility of buckle of the teeth. Moreover, since the end portion is curved by wrapping, a curving moment can be applied to the portion of the laminate to be curved while reducing the stress applied to the teeth at a position away from the end by a predetermined distance. This makes it possible to further lessen the possibility of buckle of the teeth.

[0110] According to the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the iron core is formed by curving a single laminate having a substantially hexahedral shape, and the body curving step includes: a first body curving step in which a central portion of the laminate is clamped, and both end portions of a predetermined length from ends are curved by being wrapped

around a cylindrical core member, and a second body curving step in which the curved portions that have been formed in the first step are clamped and the remaining central portion is curved by wrapping it around the core member. Hence, a single substantially hexahedral laminate is used, so that only one joining step is required, and the strength of the iron core can be improved since there are fewer joining places. Moreover, a wide area of the central portion is clamped, so that the end portions can be easily wound onto the core members

[0111] The manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the iron core being constructed by laminated magnetic plate strips, a cylindrical core proximal portion, a plurality of teeth projecting in a substantially radial direction from the core proximal portion, and slots for accommodating a winding that are formed between the teeth adjacent to each other, includes: a body curving step for wrapping a central portion of a laminate around a cylindrical core member to form the laminate into a cylindrical shape such that distal ends of teeth project from the core proximal portion; an end portion curving step for clamping the laminate, which has been curved in the body curving step, at inner and outer peripheries except end portions thereof and curving the end portions of the laminate by pressing or wrapping the end portions toward the inner periphery thereof; and a joining step for joining both end portions of the laminate. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Furthermore, the laminate is held at inner and outer peripheries thereof other than the end portions when curving the end portions, thus ensuring firm support, permitting the occurrence of buckle of teeth to be further reduced.

[0112] The manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention includes a step for accommodating a winding in slots of the substantially hexahedral laminate before at least the body curving step, and the body curving step is implemented with the winding accommodated in the slots. This makes it possible to easily provide the iron core with a uniform curvature over the entire circumference thereof, resulting in improved roundness of the cylindrical iron core. The improved roundness of the iron core allows a reduced gap relative to a magnetic pole or a magnet opposing the iron core, and a magnetic resistance in the gap can be reduced, so that a higher output of a rotating-electric machine can be achieved. Since the winding is accommodated in the substantially hexahedral laminate, the accommodating work is easy. Moreover, sectional areas of the slots decrease after curving; therefore, occupancy of the winding in the slots

can be increased with a resultant higher output of the rotating-electric machine.

[0113] In the manufacturing method for an iron core of a rotating-electric machine in accordance with the present invention, the body curving step is carried out while at least a part of the core proximal portion of the laminate is slidably guided from both sides. Hence, the laminate is guided so as to prevent the laminate from deforming in a direction of lamination, allowing the possibility of wavy deformation of the laminate to be reduced.

Claims

1. An iron core (50) of a rotating electric machine, comprising:

a substantially hexahedral laminate (15) including a plurality of magnetic strips which are laminated, each magnetic strip having a cylindrical core proximal portion (15a) and a plurality of teeth (15b);

wherein the laminate (15) has a cylindrical shape such that both end portions of the laminate abut against each other at a joining portion (16); the plurality of teeth (15b) project in a substantially radial direction from the proximal portion (15a); and slots for accommodating a winding are located between the teeth (15a) adjacent to each other; wherein both end portions (15c) of the core proximal portion (15a) of the laminate (115) have a lower rigidity than that of the remainder thereof.

2. An iron core according to claim 1, wherein both end portions (15c) of the core proximal portion (15a) of the laminate (115) are provided with thinner portions (15c) that are thinner in the radial direction so as to have a lower rigidity.
3. An iron core according to claim 2, wherein a filling member (17) for making a diameter of a circumferential end of the core proximal portion (15a) identical to that of the remainder is welded to the thinner portions (15c).
4. A manufacturing method for an iron core of a rotating electric machine, the iron core including laminated magnetic plate strips, a cylindrical core proximal portion (15a), a plurality of teeth (15b) projecting in a substantially radial direction from the core proximal portion (15a), and slots for accommodating a winding that are located between the teeth (15b) adjacent to each other, the manufacturing method comprising the steps of:

providing a substantially hexahedral laminate

(15) having a core proximal portion (15a) both end portions of which having a lower rigidity than that of the remainder thereof;

curving both end portions of the laminate so that the core proximal portion (15a) obtains a predetermined curvature;

curving the entire laminate (15) into a cylindrical shape by wrapping it around a cylindrical core member (73) so that distal ends of the teeth (15b) project from the core proximal portion (15a); and

joining both end portions of the laminate.

5. A manufacturing method according to claim 4, wherein the laminate (15) is clamped between a first fixing jig (61) disposed at the core proximal portion (15a) and a second fixing jig (63, 64) disposed on the teeth (15b) such that the end portions of the laminate (15) project by a predetermined length, and the end portions of the laminate are curved by pressing the end portions in a direction in which the teeth (15b) project by a pressing jig (71) in the end portion curving step, an end portion of the second fixing jig (63, 64) that is adjacent to the teeth being provided with an arc or linear slope (63a, 64a) that becomes farther from the teeth (15b) toward an end thereof.

6. A manufacturing method according to claim 4, wherein the laminate (15) is clamped between a first fixing jig (61) disposed at the core proximal portion (15a) and a second fixing jig (63, 64) disposed at the teeth (15b) such that the end portions of the laminate (15) project by a predetermined length, and a closely contacting jig (72) having an L-shaped section is placed in close contact with a corner on the core proximal portion (15a) of the end of the laminate (15), and the end portions of the laminate (15) are curved using the closely contacting jig (72) such that they are wrapped toward the teeth (15b), an end portion of the second fixing jig (63, 64) that is adjacent to the teeth being provided with an arc or linear slope (63a, 64a) that becomes farther from the teeth (15b) toward an end thereof.

7. A manufacturing method according to any one of claims 4 to 6, wherein

the iron core (50) is formed by curving a single laminate (15) having a substantially hexahedral shape; and

in a first body curving step a central portion of the laminate (15) is clamped, and both end portions of a predetermined length from the ends

of the laminate (15) are curved by being wrapped around a cylindrical core member (73), and

in a second body curving step the curved portions that have been formed are clamped, and a remaining central portion of the laminate (15) is curved by being wrapped around the core member (73).

8. A manufacturing method for an iron core of a rotating-electric machine constructed by laminated magnetic plate strips, a cylindrical core proximal portion (15a), a plurality of teeth (15b) projecting in a substantially radial direction from the core proximal portion (15a), and slots for accommodating a winding that are formed between the teeth (15b) adjacent to each other, the manufacturing method comprising the steps of:

providing a substantially hexahedral laminate (15) having a core proximal portion (15a) both end portions of which having a lower rigidity than that of the remainder thereof;

wrapping a central portion of the laminate (15) around a cylindrical core member (73) to form the laminate (15) into a cylindrical shape such that distal ends of the teeth (15b) project from the core proximal portion (15a);

clamping the laminate (15) which has been curved, at inner and outer peripheries except end portions thereof, and curving the end portions of the laminate (15) by pressing or wrapping the end portions toward the inner periphery thereof; and

joining both end portions of the laminate.

9. A manufacturing method according to any one of claims 4 to 8, further comprising accommodating the winding in the slots of the substantially hexahedral laminate before at least the laminate (15) is wrapped around the cylindrical core member (73); and the laminate (15) is wrapped around the cylindrical core member (73) with the winding accommodated in the slots.

Patentansprüche

1. Eisenkern (50) einer sich drehenden elektrischen Maschine, welcher aufweist:

ein im Wesentlichen sechsfaches Laminat (15), das mehrere laminierte, magnetische

Streifen aufweist, wobei jeder magnetische Streifen einen zum zylindrischen Kern proximalen Abschnitt (15a) und mehrere Zähne (15b) aufweist;

wobei das Laminat (15) zylinderförmig ist, so dass beide Endabschnitte des Laminats aneinander an einem Verbindungsabschnitt (16) anstoßen; die mehreren Zähne (15b) in im Wesentlichen radialer Richtung gegenüber dem proximalen Abschnitt (15a) vorstehen; und Nuten zur Aufnahme einer Wicklung zwischen den Zähnen (15a) einander benachbart angeordnet sind; wobei beide Endabschnitte (15c) des zum Kern proximalen Abschnitts (15a) des Laminats (115) eine geringere Steifigkeit aufweisen als dessen Rest.

2. Eisenkern nach Anspruch 1, bei welchem beide Endabschnitte (15c) des zum Kern proximalen Abschnitts (15a) des Laminats (115) mit dünneren Abschnitten (15c) versehen sind, die in Radialrichtung dünner sind, so dass sie eine geringere Steifigkeit aufweisen.

3. Eisenkern nach Anspruch 2, bei welchem ein Füllteil (17), das dazu dient, den Durchmesser eines Umfangendes des zum Kern proximalen Abschnitts (15a) gleich jenem des Rests auszubilden, an die dünneren Abschnitte (15c) geschweißt ist.

4. Herstellungsverfahren für einen Eisenkern einer sich drehenden elektrischen Maschine, wobei der Eisenkern laminierte Magnetplattenstreifen aufweist, einen zum zylindrischen Kern proximalen Abschnitt (15a), mehrere Zähne (15b), die in im Wesentlichen radialer Richtung gegenüber dem zum Kern proximalen Abschnitt (15a) vorstehen, und Nuten zur Aufnahme einer Wicklung, die einander benachbart zwischen den Zähnen (15b) angeordnet sind, mit folgenden Schritten:

Bereitstellung eines im Wesentlichen sechsflächigen Laminats (15), das einen zum Kern proximalen Abschnitt (15a) aufweist, dessen beide Endabschnitte eine geringere Steifigkeit aufweisen, als dessen Rest;

Biegen beider Endabschnitte des Laminats so, dass der zum Kern proximale Abschnitt (15a) eine vorbestimmte Krümmung erhält;

Biegen des gesamten Laminats (15) in eine Zylinderform, durch Schlingen es um ein zylindrisches Kernteil (73), so dass distale Enden der Zähne (15b) gegenüber dem zum Kern proximalen Abschnitt (15a) vorstehen; und

Verbinden beider Endabschnitte des Laminats.

5. Herstellungsverfahren nach Anspruch 4, bei welchem das Laminat (15) zwischen einer ersten Aufspannvorrichtung (61), die an dem zum Kern proximalen Abschnitt (15a) angeordnet ist, und einer zweiten Aufspannvorrichtung (63, 64) eingeklemmt wird, die auf den Zähnen (15b) angeordnet ist, so dass die Endabschnitte des Laminats (15) um eine vorbestimmte Länge vorstehen, und die Endabschnitte des Laminats dadurch gebogen werden, dass die Endabschnitte in eine Richtung gedrückt werden, in welcher die Zähne (15b) vorstehen, durch eine Druckspannvorrichtung (71), in dem Schritt zum Biegen des Endabschnitts, und ein Abschnitt der zweiten Aufspannvorrichtung (63, 64), der in der Nähe der Zähne liegt, mit einem Bogen oder einer geraden Schrägfläche (63a, 64a) versehen ist, der bzw. die zum Ende hin weiter von den Zähnen (15b) entfernt ist.

6. Herstellungsverfahren nach Anspruch 4, bei welchem das Laminat (15) zwischen einer ersten Aufspannvorrichtung (61), die an dem zum Kern proximalen Abschnitt (15a) angeordnet ist, und einer zweiten Aufspannvorrichtung (63, 64) eingeklemmt wird, die an den Zähnen (15b) angeordnet ist, so dass die Endabschnitte des Laminats (15) um eine vorbestimmte Länge vorstehen, und eine eng berührende Spannvorrichtung (72), die einen L-förmigen Schnitt aufweist, in enger Berührung mit einer Ecke auf dem zum Kern proximalen Abschnitt (15a) des Endes des Laminats (15) angeordnet wird, und die Endabschnitte des Laminats (15) gebogen werden, unter Verwendung der eng berührenden Spannvorrichtung (72), so dass sie zu den Zähnen (15b) hin herumgeschlungen werden, und ein Endabschnitt der zweiten Aufspannvorrichtung (63, 64), der sich in der Nähe der Zähne befindet, mit einem Bogen oder einer geraden Schrägfläche (63a, 64a) versehen ist, der bzw. die zum Ende hin sich weiter von den Zähnen (15b) entfernt.

7. Herstellungsverfahren nach einem der Ansprüche 4 bis 6, bei welchem der Eisenkern (50) durch Biegen eines einzigen Laminats (15) ausgebildet wird, das eine im Wesentlichen sechsflächige Form aufweist; und in einem ersten Körperbiegeschritt ein zentraler Abschnitt des Laminats (15) eingeklemmt wird, und beide Endabschnitte einer vorbestimmten Länge von den Enden des Laminats (15) aus dadurch gebogen werden, dass sie um ein zylindrisches Kernteil (73) herumgeschlungen werden, und in einem zweiten Körperbiegeschritt die ausgebildeten, gebogenen Abschnitte eingeklemmt werden, und ein verbleibender, zentraler Abschnitt des Laminats (15) dadurch gebogen wird, dass er um

das Kernteil (73) herumgeschlungen wird.

8. Herstellungsverfahren für einen Eisenkern einer sich drehenden elektrischen Maschine, welche laminierte Magnetplattenstreifen aufweist, einen zum zylindrischen Kern proximalen Abschnitt (15a), mehrere Zähne (15b), die in im Wesentlichen radialer Richtung gegenüber dem zum Kern proximalen Abschnitt (15a) vorstehen, und Nuten zur Aufnahme einer Wicklung, die einander benachbart zwischen den Zähnen (15b) vorgesehen sind, mit folgenden Schritten:

Bereitstellung eines im Wesentlichen sechsflächigen Laminats (15), das einen zum Kern proximalen Abschnitt (15a) aufweist, dessen beide Endabschnitte eine geringere Steifigkeit aufweisen als der Rest; Schlingen eines zentralen Abschnitts des Laminats (15) um ein zylindrisches Kernteil (73) zur Ausbildung des Laminats (15) mit Zylinderform, so dass distale Enden der Zähne (15b) gegenüber dem zum Kern proximalen Abschnitt (15a) vorstehen;

Einklemmen des Laminats (15), das gebogen wurde, am Innen- und Außenumfang mit Ausnahme seiner Endabschnitte, und Biegen der Endabschnitte des Laminats (15) durch Drücken oder Schlingen der Endabschnitte zu seinem Innenumfang; und

Verbinden beider Endabschnitte des Laminats.

9. Herstellungsverfahren nach einem der Ansprüche 4 bis 8, welches weiterhin umfasst, die Wicklung in die Nuten des im Wesentlichen sechsflächigen Laminats aufzunehmen, bevor zumindest das Laminat (15) um das zylindrische Kernteil (73) herumgeschlungen wird; und das Laminat (15) mit der in den Nuten aufgenommenen Wicklung um das zylindrische Kernteil (73) herumgeschlungen wird.

Revendications

1. Noyau de fer (50) pour machine électrique tournante, comprenant :

un élément feuilleté sensiblement hexaèdre (15) comprenant une pluralité de bandes magnétiques qui sont feuilletées, chaque bande magnétique ayant une partie proximale de noyau cylindrique (15a) et une pluralité de dents (15b) ;

dans lequel l'élément feuilleté (15) a une forme cylindrique telle que les deux parties d'extrémité

de l'élément feuilleté soient en butée l'une contre l'autre au niveau d'une partie de jonction (16) ;

la pluralité de dents (15b) font saillie dans une direction sensiblement radiale à partir de la partie proximale (15a) ; et

des fentes pour loger un enroulement sont situées entre les dents (15a) adjacentes entre elles ; dans lequel les deux parties d'extrémité (15c) de la partie proximale de noyau (15a) de l'élément feuilleté (115) ont une rigidité inférieure à celle du reste de celui-ci.

2. Noyau de fer selon la revendication 1, dans lequel les deux parties d'extrémité (15c) de la partie proximale de noyau (15a) de l'élément feuilleté (115) sont munies de parties plus minces (15c) qui sont plus minces dans la direction radiale de manière à avoir une rigidité inférieure.

3. Noyau de fer selon la revendication 2, dans lequel un élément de remplissage (17) pour rendre un diamètre d'une extrémité circonférentielle de la partie proximale de noyau (15a) identique à celui du reste est soudé aux parties plus minces (15c).

4. Procédé de fabrication d'un noyau de fer d'une machine électrique tournante, le noyau de fer comprenant des bandes plates magnétiques feuilletées, une partie proximale de noyau cylindrique (15a), une pluralité de dents (15b) faisant saillie dans une direction sensiblement radiale à partir de la partie proximale de noyau (15a) et des fentes pour loger un enroulement qui sont situées entre les dents (15b) adjacentes entre elles, le procédé de fabrication comprenant les étapes consistant à :

fournir un élément feuilleté sensiblement hexaèdre (15) ayant une partie proximale de noyau (15a) dont les deux parties d'extrémité ont une rigidité inférieure à celle du reste de celui-ci ;

courber les deux parties d'extrémité de l'élément feuilleté de manière que la partie proximale de noyau (15a) reçoive une courbure prédéterminée ;

courber tout l'élément feuilleté (15) sous une forme cylindrique en l'enroulant autour d'un élément de noyau cylindrique (73) de manière que des extrémités distales des dents (15b) fassent saillie à partir de la partie proximale de noyau (15a) ; et

joindre les deux parties d'extrémité de l'élément feuilleté.

5. Procédé de fabrication selon la revendication 4, dans lequel l'élément feuilleté (15) est serré à bloc entre un premier gabarit de fixation (61) disposé au niveau de la partie proximale de noyau (15a) et un

- deuxième gabarit de fixation (63, 64) disposé sur les dents (15b) de manière que les parties d'extrémité de l'élément feuilleté (15) dépassent d'une longueur prédéterminée et que les parties d'extrémité de l'élément feuilleté soient courbées en comprimant les parties d'extrémité dans une direction dans laquelle les dents (15b) font saillie par un gabarit de compression (71) dans l'étape de courbure des parties d'extrémité, une partie d'extrémité du deuxième gabarit de fixation (63, 64) qui est adjacente aux dents étant pourvu d'un biais linéaire ou en arc (63a, 64a) qui devient plus éloigné des dents (15b) vers une extrémité de celui-ci.
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6. Procédé de fabrication selon la revendication 4, dans lequel l'élément feuilleté (15) est serré à bloc entre un premier gabarit de fixation (61) disposé au niveau de la partie proximale de noyau (15a) et un deuxième gabarit de fixation (63, 64) disposé sur les dents (15b) de manière que les parties d'extrémité de l'élément feuilleté (15) dépassent d'une longueur prédéterminée, et un gabarit de contact serré (72) ayant une section en L est placé en contact serré avec un coin sur la partie proximale de noyau (15a) de l'extrémité de l'élément feuilleté (15) et les parties d'extrémité de l'élément feuilleté (15) sont courbées en utilisant le gabarit de contact serré (72) de manière qu'elles soient enroulées vers les dents (15b), une partie d'extrémité du deuxième gabarit de fixation (63, 64) qui est adjacente aux dents étant pourvu d'un biais linéaire ou en arc (63a, 64a) qui devient plus éloigné des dents (15b) vers une extrémité de celui-ci.
- 15
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7. Procédé de fabrication selon l'une quelconque des revendications 4 à 6, dans lequel le noyau de fer (50) est formé en courbant un unique élément feuilleté (15) ayant une forme sensiblement hexaèdre ; et dans une première étape de courbage du corps, une partie centrale de l'élément feuilleté (15) est serrée à bloc et les deux parties d'extrémité d'une longueur prédéterminée à partir des extrémités de l'élément feuilleté (15) sont courbées en étant enroulées autour d'un élément de noyau cylindrique (73) ; et dans une deuxième étape de courbage du corps, les parties courbées qui ont été formées sont serrées à bloc et une partie centrale restante de l'élément feuilleté (15) est courbée en étant enroulée autour de l'élément de noyau (73).
- 35
- 40
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- 50
8. Procédé de fabrication d'un noyau de fer d'une machine électrique tournante constitué par des bandes plates magnétiques feuilletées, une partie proximale de noyau cylindrique (15a), une pluralité de dents (15b) faisant saillie dans une direction sensiblement radiale à partir de la partie proximale de
- 55

noyau (15a) et des fentes pour loger un enroulement qui sont situées entre les dents (15b) adjacentes entre elles, le procédé de fabrication comprenant les étapes consistant à :

fournir un élément feuilleté sensiblement hexaèdre (15) ayant une partie proximale de noyau (15a) dont les deux parties d'extrémité ont une rigidité inférieure à celle du reste de celui-ci ;

enrouler une partie centrale de l'élément feuilleté (15) autour d'un élément de noyau cylindrique (73) pour former l'élément feuilleté (15) sous une forme cylindrique telle que des extrémités distales des dents (15b) fassent saillie à partir de la partie proximale de noyau (15a) ;

serrer à bloc l'élément feuilleté (15) qui a été courbé, au niveau des périphéries intérieure et extérieure sauf des parties d'extrémité de celui-ci, et courber les parties d'extrémité de l'élément feuilleté (15) en comprimant ou enroulant les parties d'extrémité vers la périphérie intérieure de celui-ci ; et

joindre les deux parties d'extrémité de l'élément feuilleté.

9. Procédé de fabrication selon l'une quelconque des revendications 4 à 8, comprenant en outre l'étape consistant à loger l'enroulement dans les fentes de l'élément feuilleté sensiblement hexaèdre avant au moins que l'élément feuilleté (15) soit enroulé autour de l'élément de noyau cylindrique (73) ; et

L'élément feuilleté (15) est enroulé autour de l'élément de noyau cylindrique (73) avec l'enroulement logé dans les fentes.

FIG. 1A

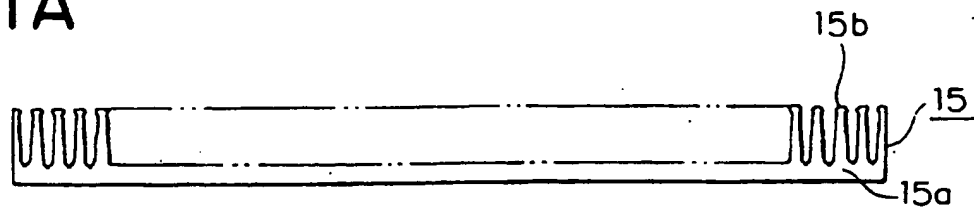


FIG. 1B

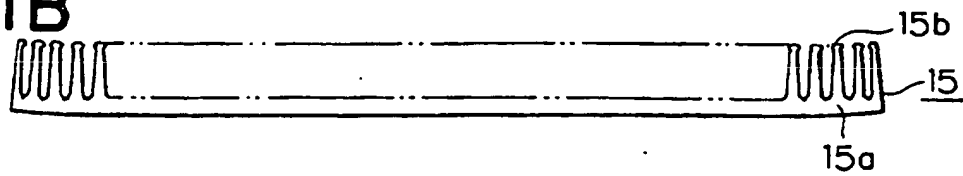


FIG. 1C

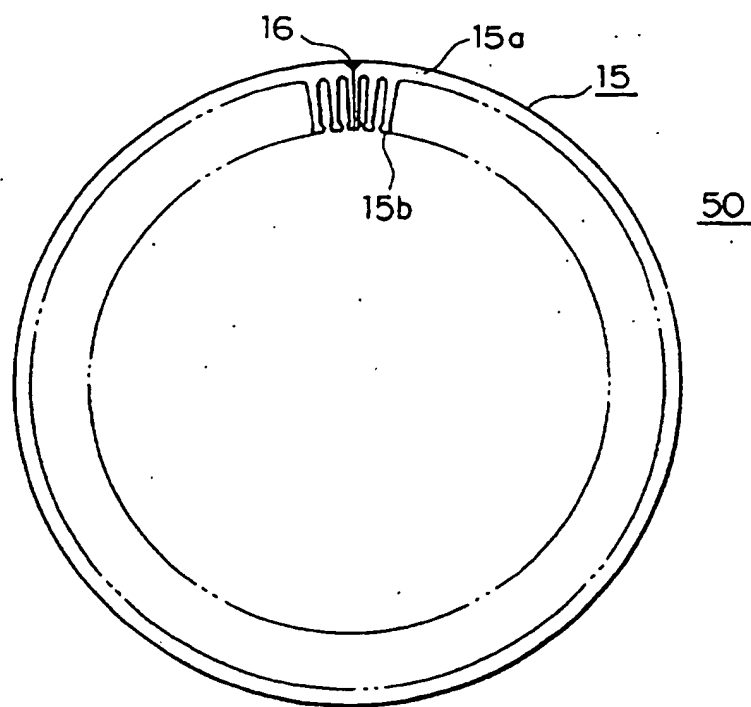


FIG. 2

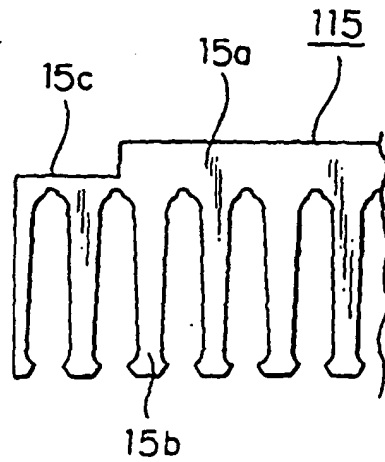


FIG. 3A

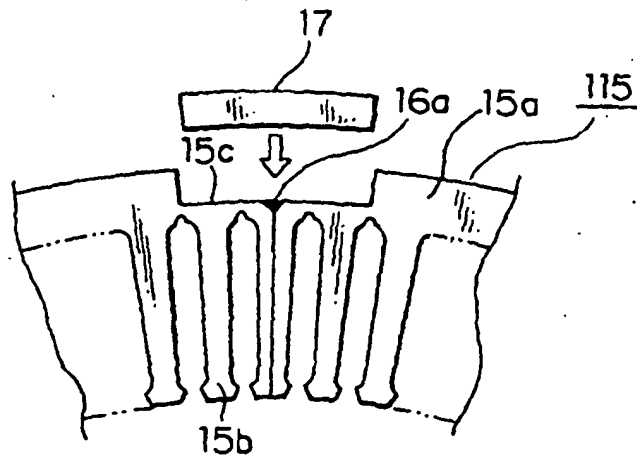


FIG. 3B

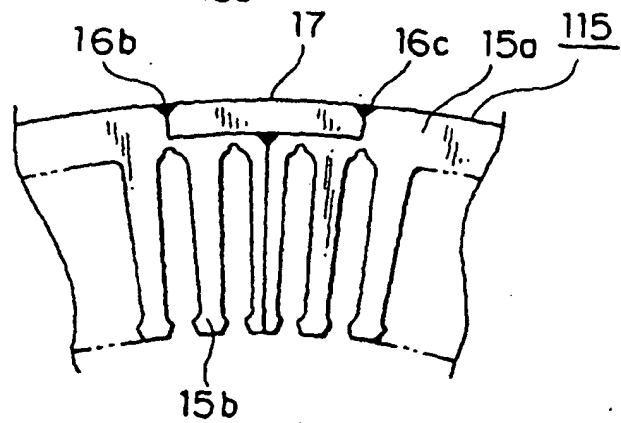


FIG. 4

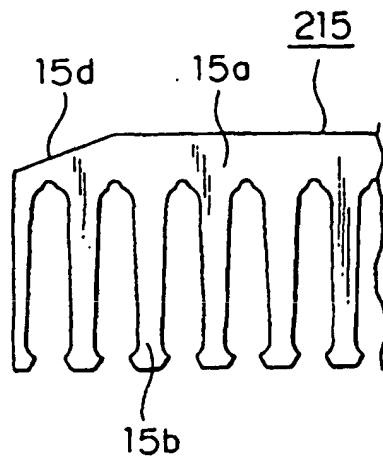


FIG. 5

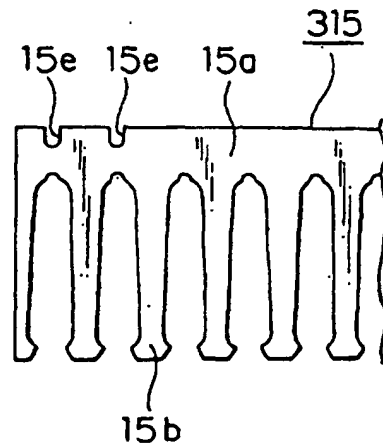


FIG. 6

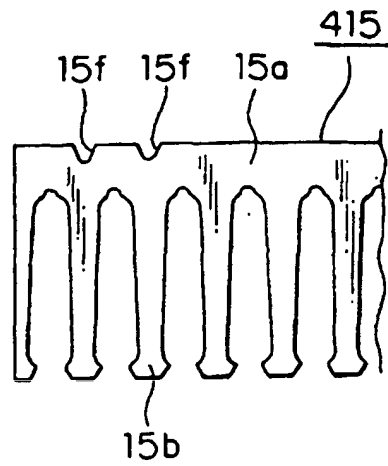


FIG. 7

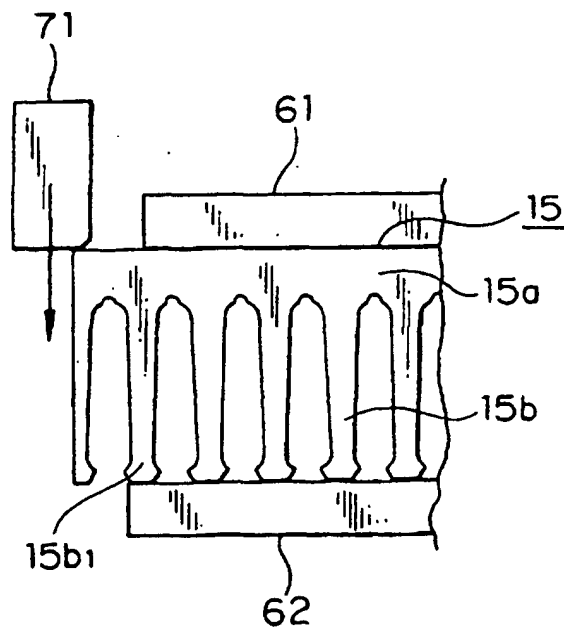


FIG. 8

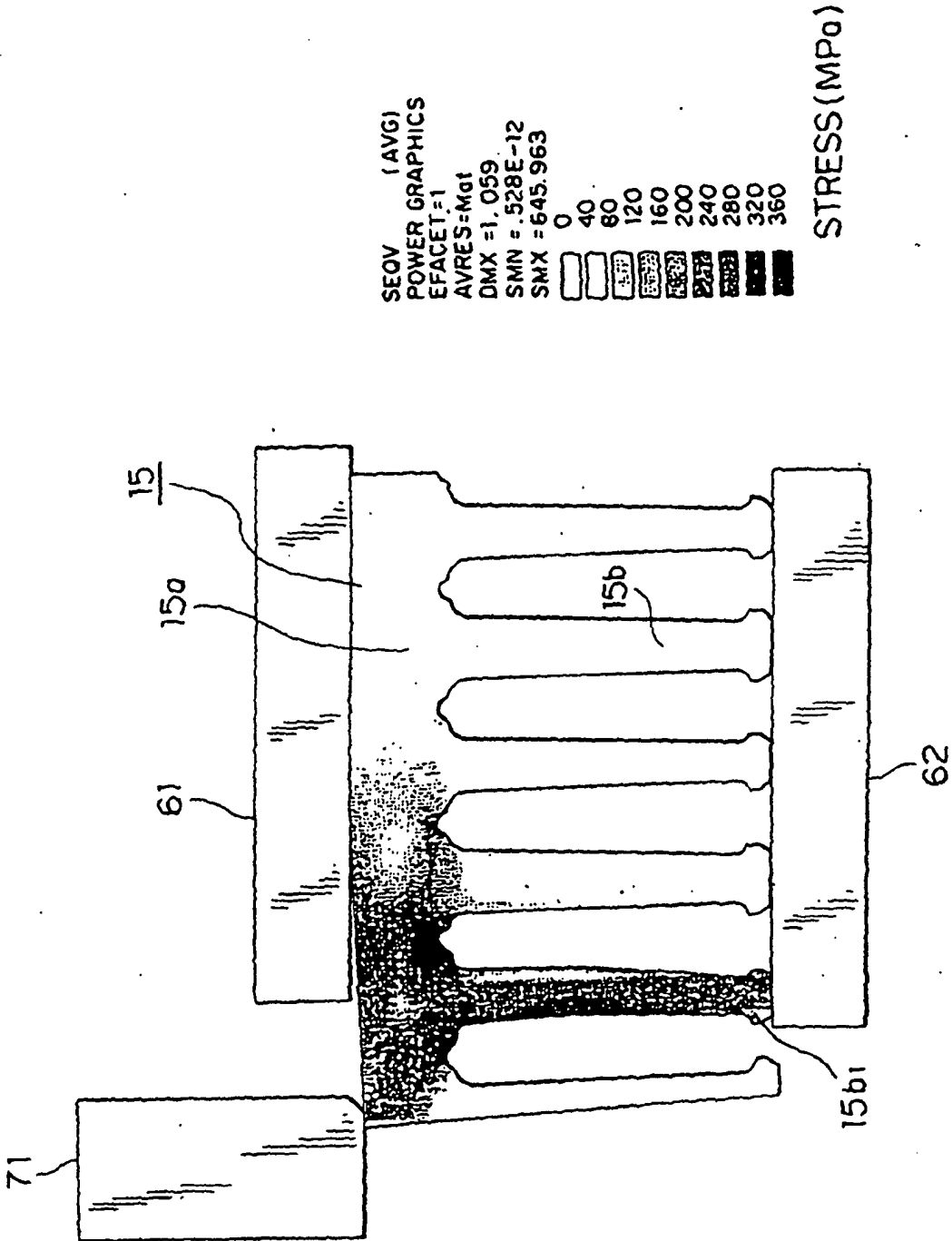


FIG. 9

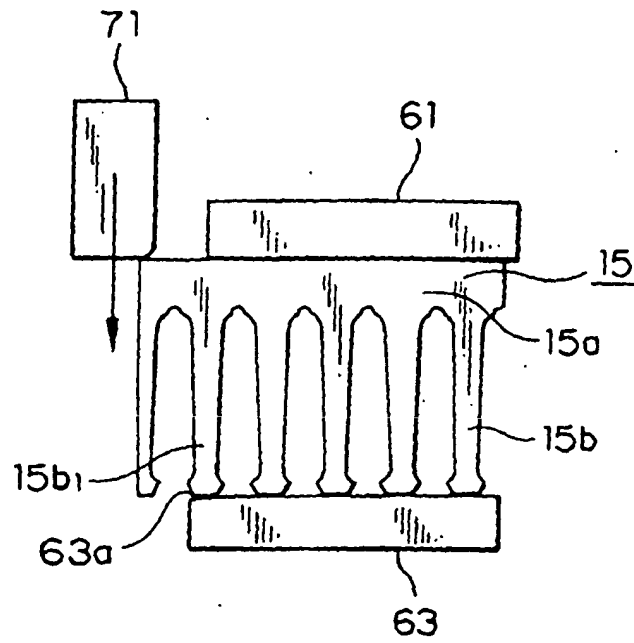


FIG. 10

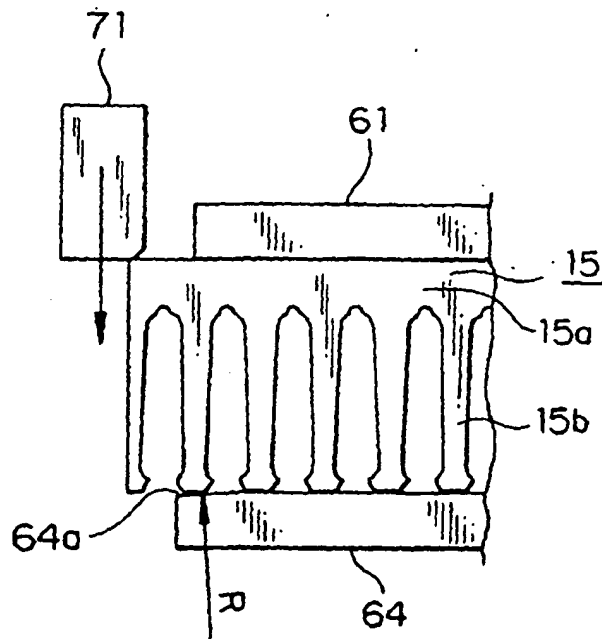


FIG. 11A FIG. 11B

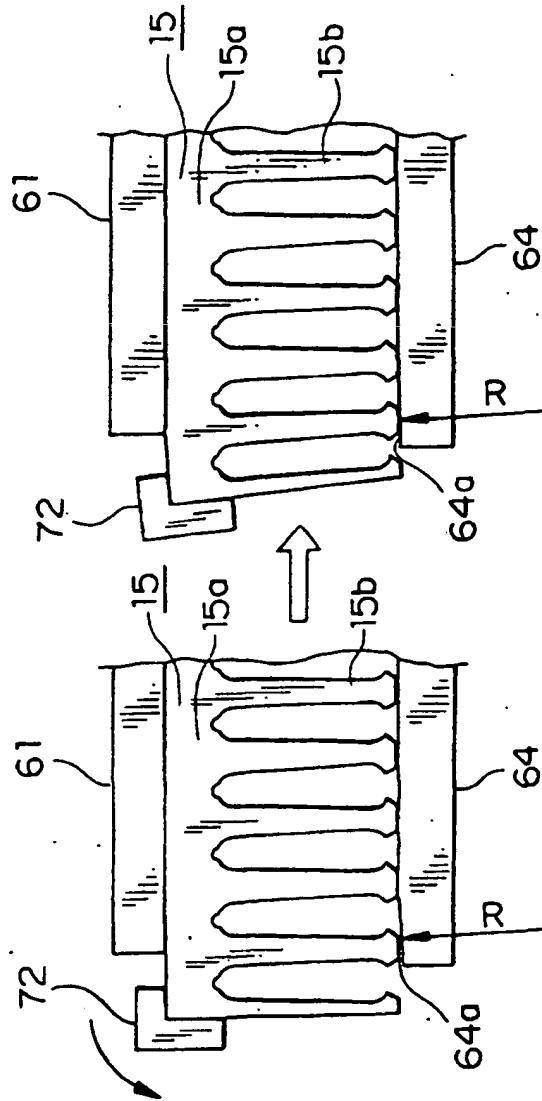


FIG. 12

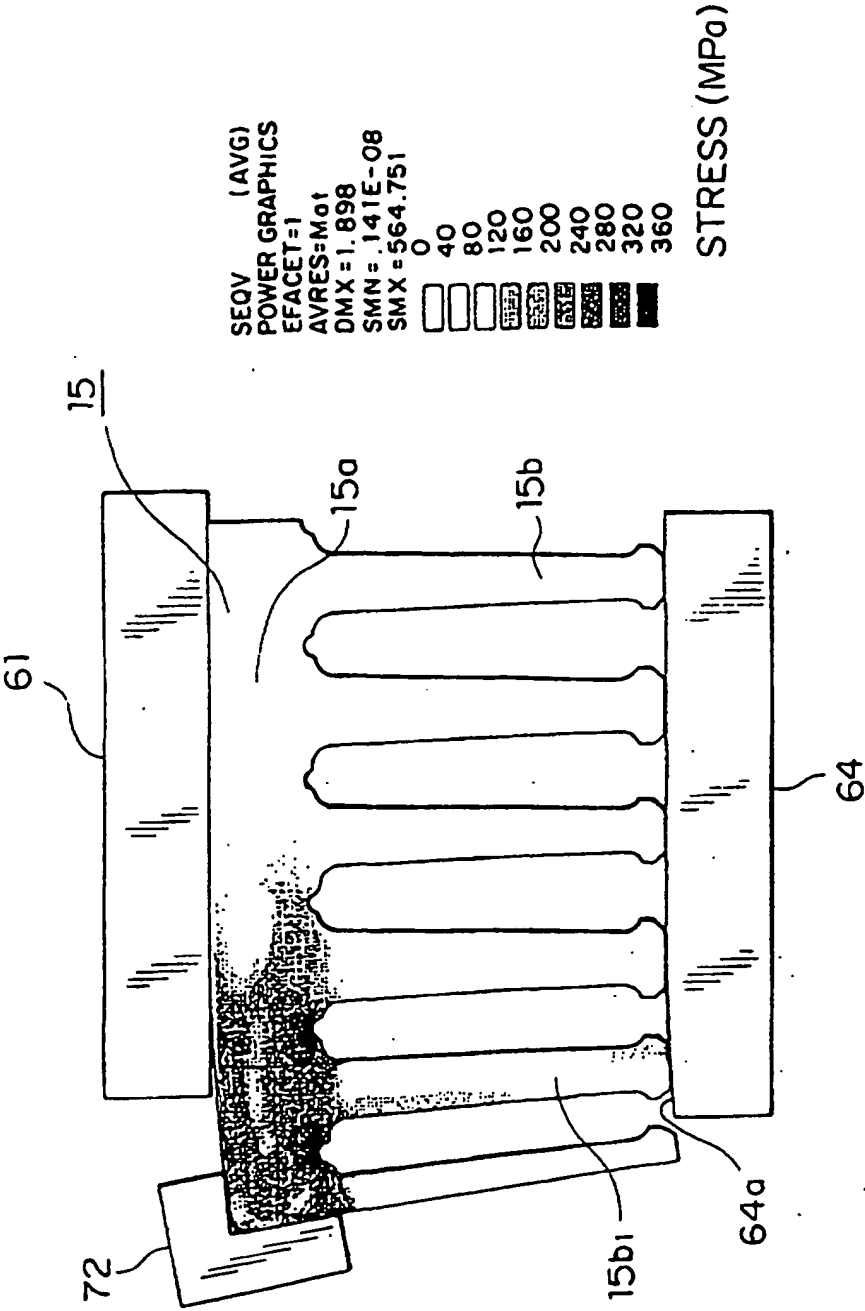


FIG. 13A

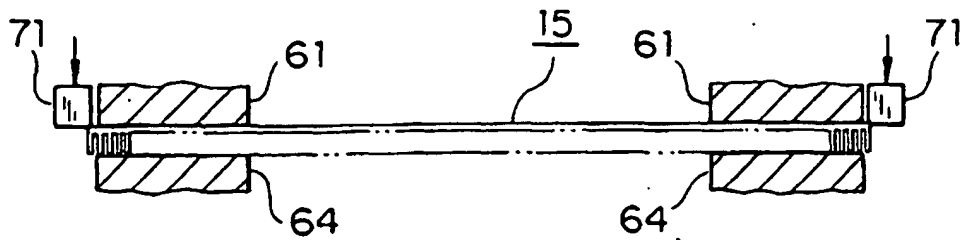


FIG. 13B

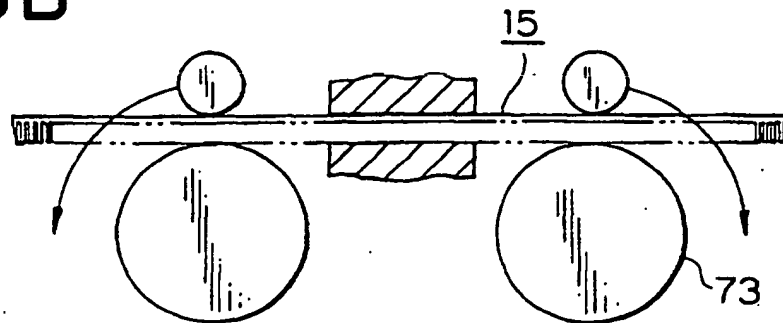


FIG. 13C

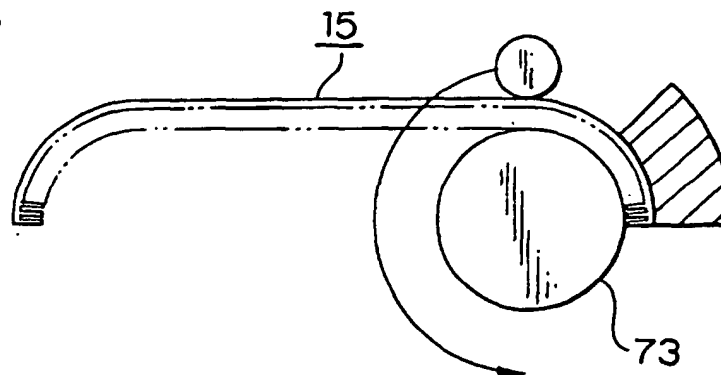


FIG. 13D

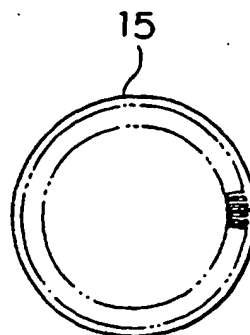


FIG. 14A

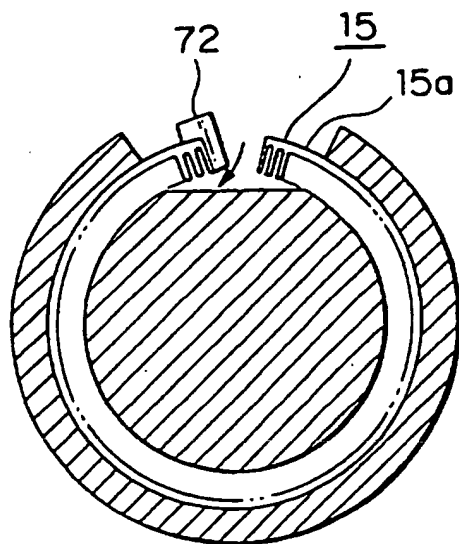


FIG. 14B

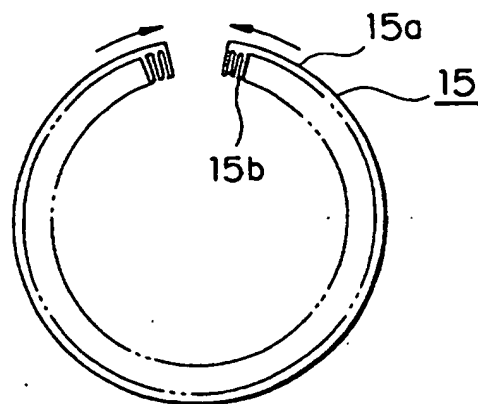


FIG. 14C

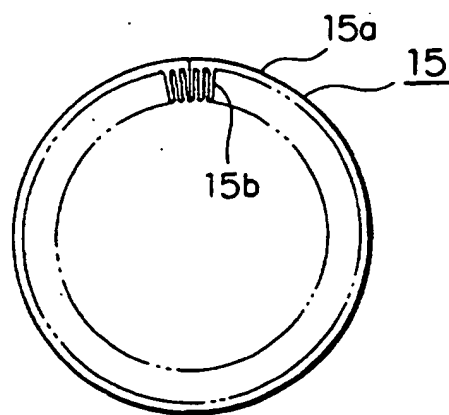


FIG. 15A

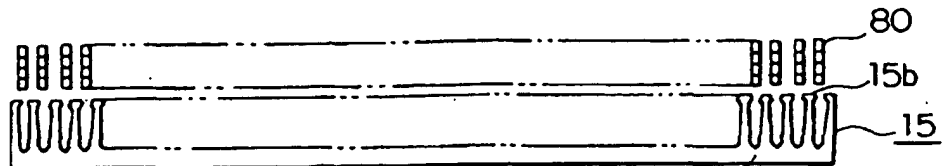


FIG. 15B

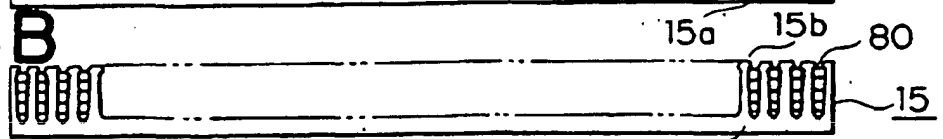


FIG. 15C

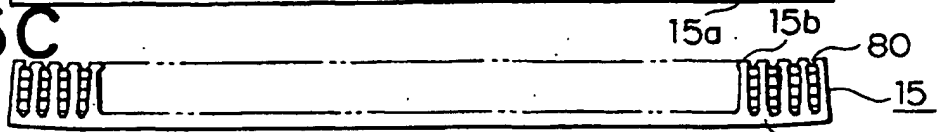


FIG. 15D

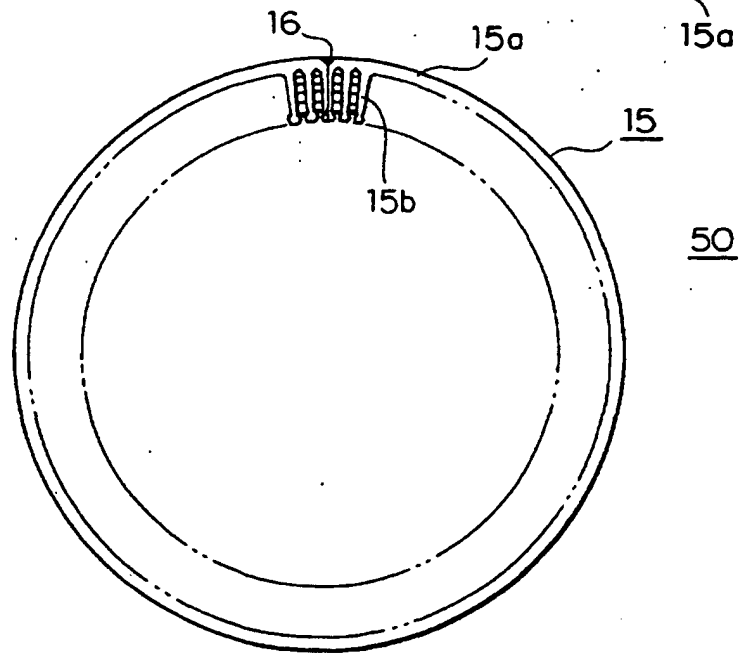


FIG. 16A

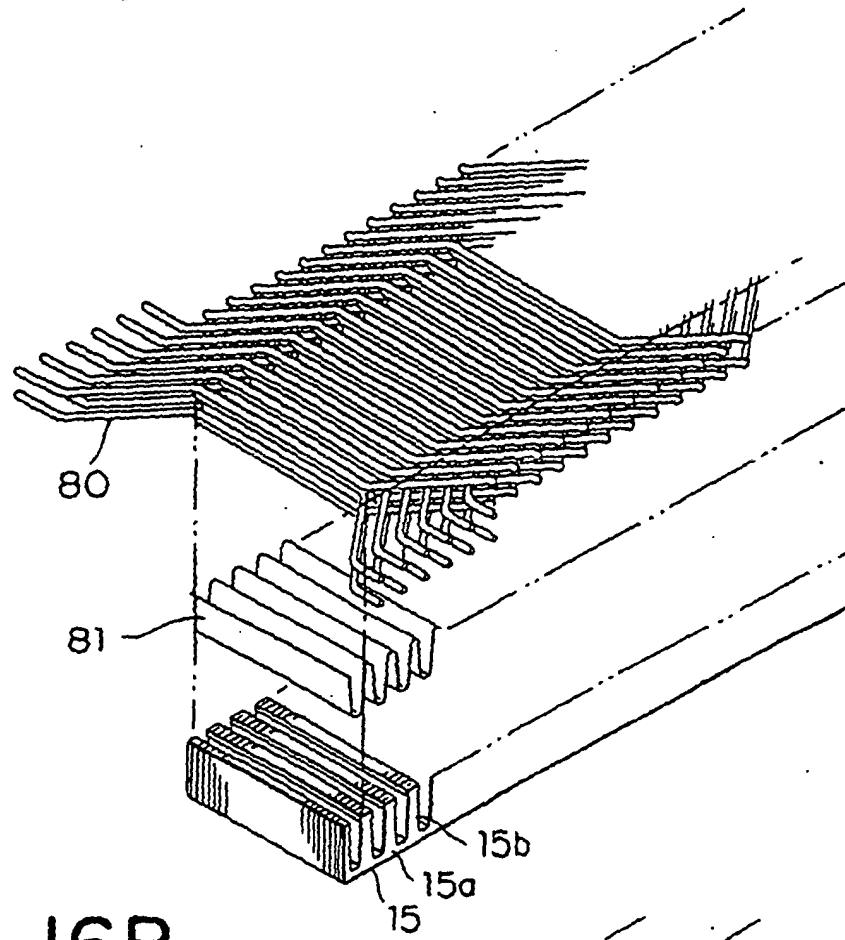


FIG. 16B

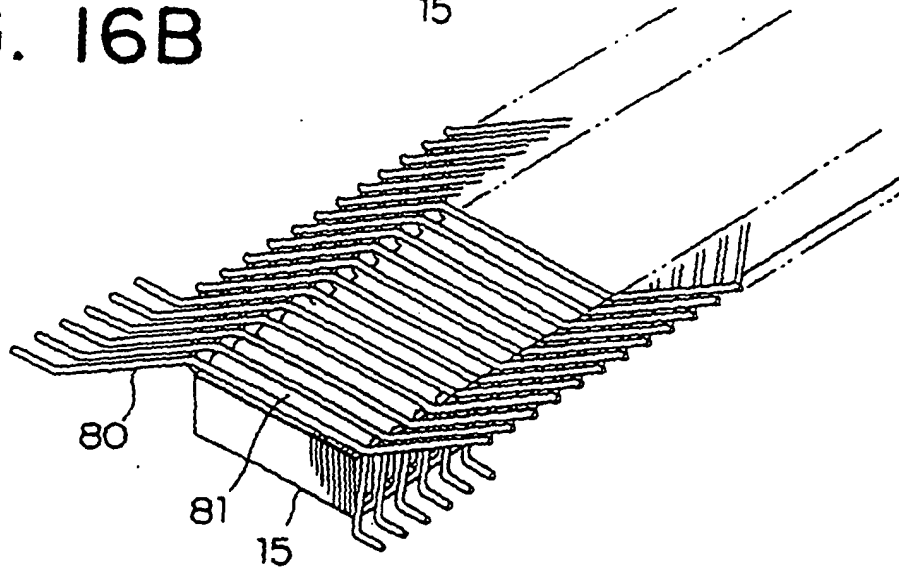


FIG. 17

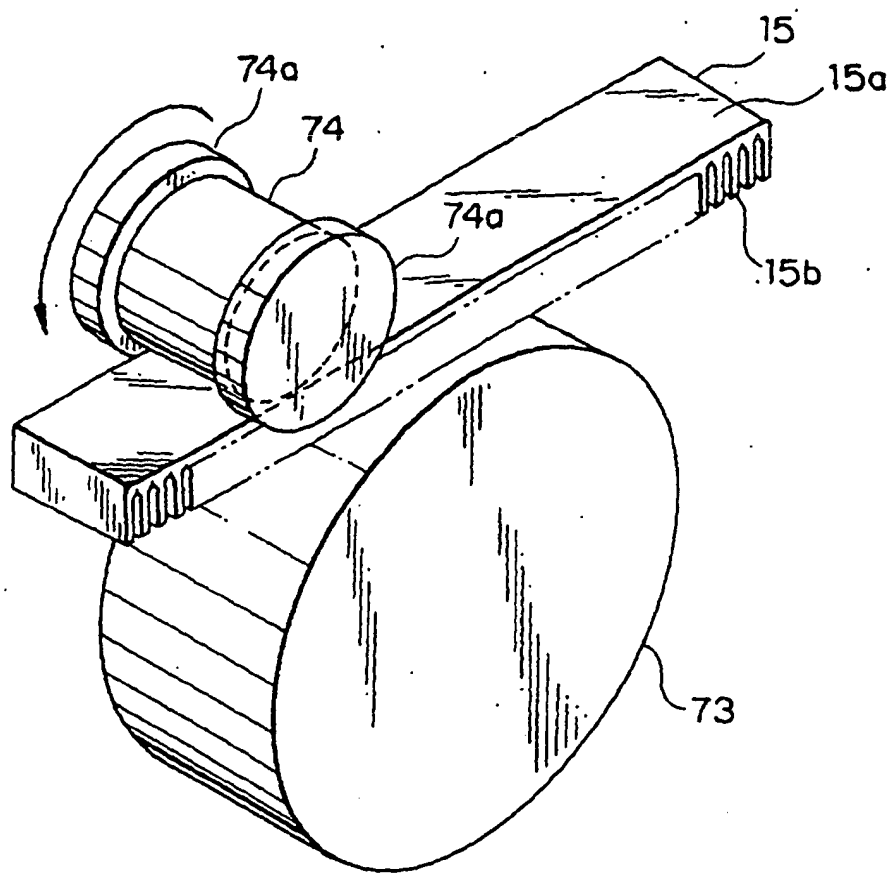


FIG. 18A

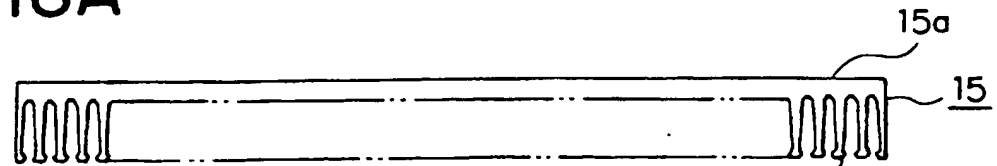


FIG. 18B

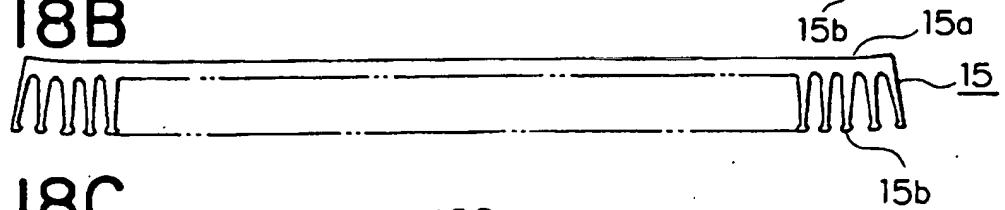


FIG. 18C

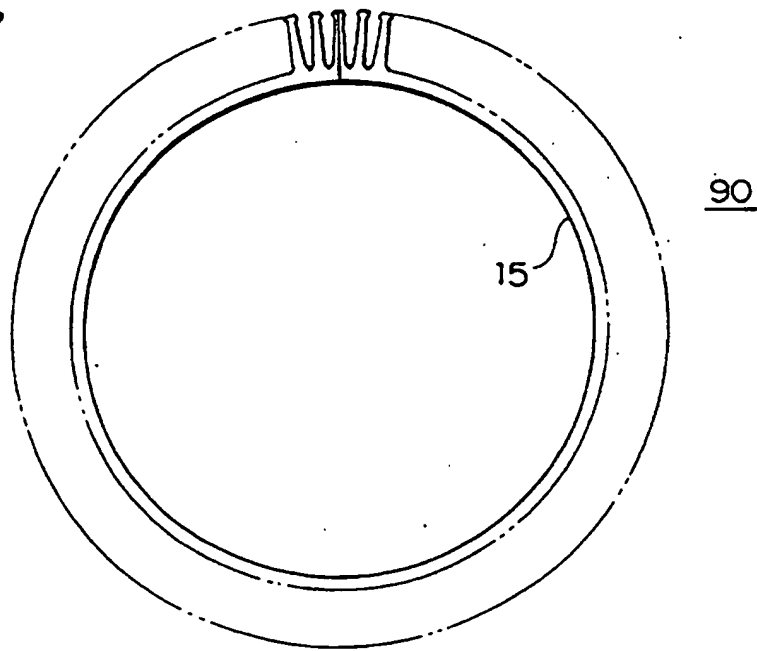


FIG. 19

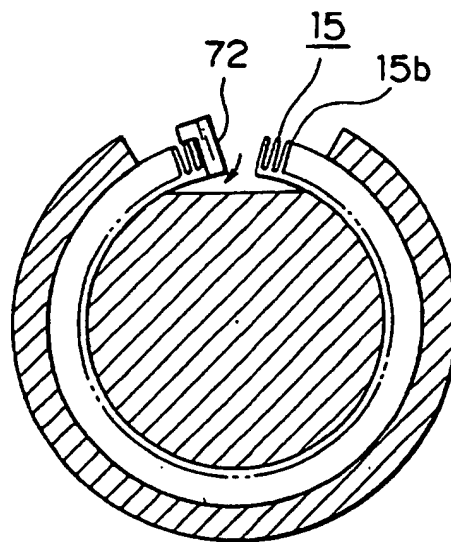


FIG. 20

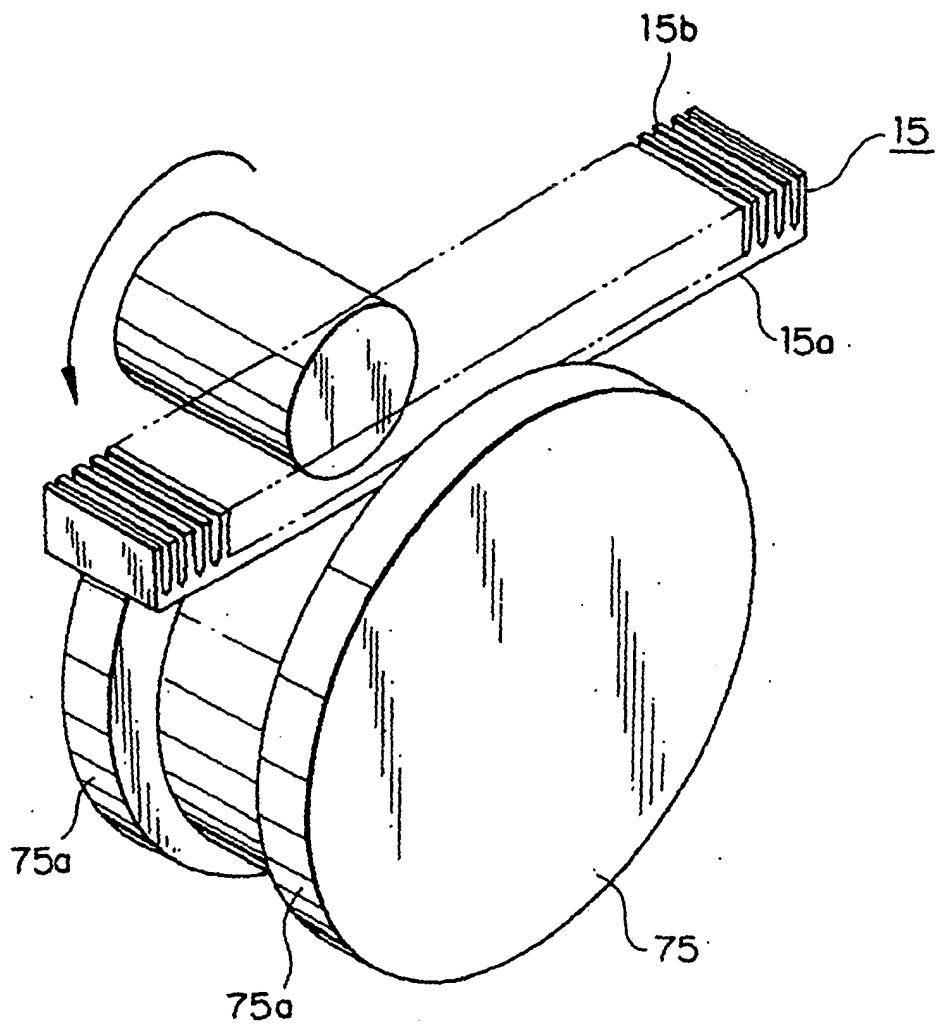


FIG. 21
PRIOR ART

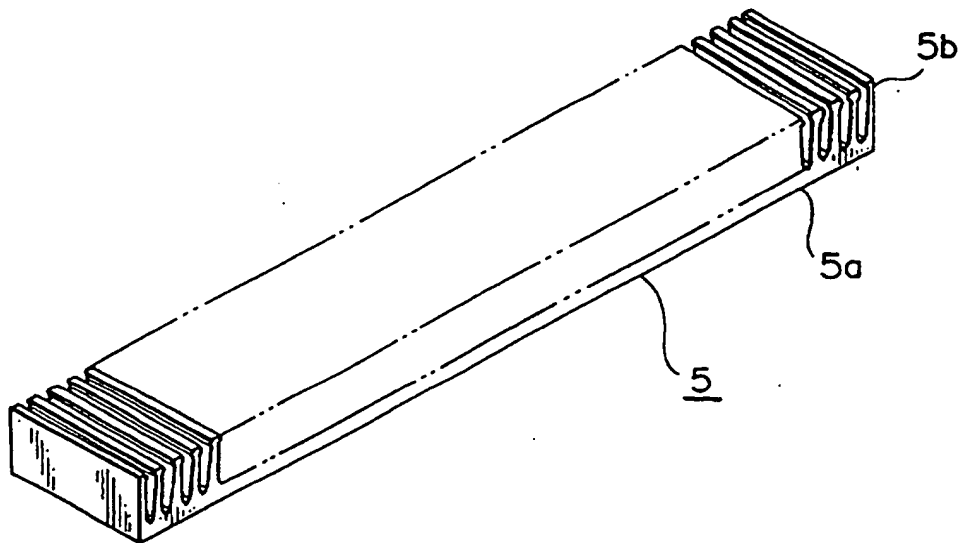


FIG. 22

PRIOR ART

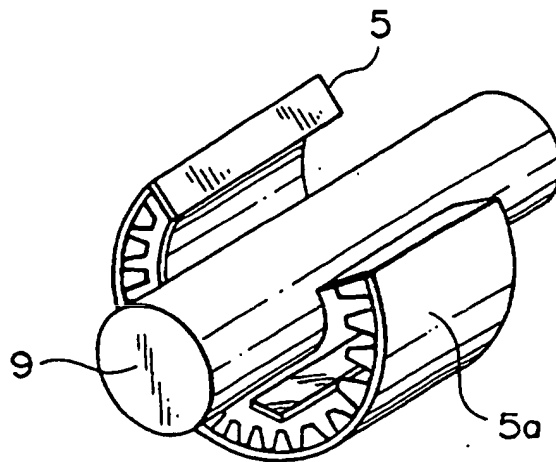


FIG. 23

PRIOR ART

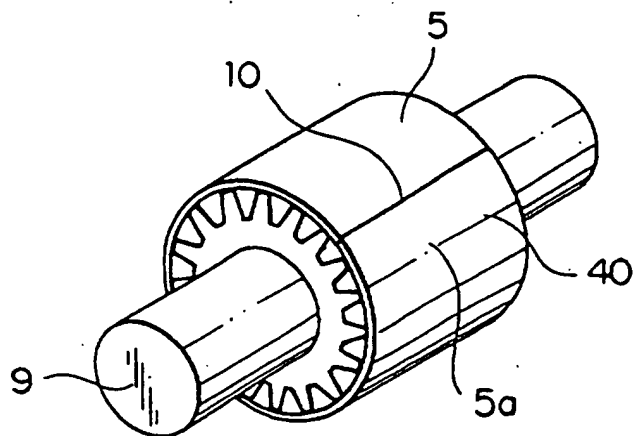


FIG. 24
PRIOR ART

